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PHYSICAL EDUCATION.

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REMEDIAL EDUCATION (*continued*).

THE vicissitudes necessarily incident to an out-door and primitive mode of life are never the first causes of any disease, though they may sometimes betray its presence. *Bronchitis*, nowadays perhaps the most frequent of all infantile diseases, makes no exception to this rule; a draught of cold air may reveal the latent progress of the disorder, but its cause is long confinement in a vitiated and overheated atmosphere, and its proper remedy ventilation and a mild, phlegm-loosening (saccharine) diet, warm sweet milk, sweet oatmeal-porridge, or honey-water. Select an airy bedroom and do not be afraid to open the windows; among the children of the Indian tribes who brave in open tents the terrible winters of the Hudson Bay territory, bronchitis, croup, and diphtheria are wholly unknown; and what we call "taking cold" might often be more correctly described as taking *hot;* glowing stoves, and even open fires, in a night-nursery, greatly aggravate the pernicious effects of an impure atmosphere. The first paroxysm of *croup* can be promptly relieved by very simple remedies: fresh air and a rapid forward-and-backward movement of the arms, combined in urgent cases with the application of a flesh-brush (or piece of flannel) to the neck and the upper part of the chest. Paregoric and poppy-sirup stop the cough by lethargizing the irritability and thus preventing the discharge of the phlegm till its accumulation produces a second and far more dangerous paroxysm. These second attacks of croup (after the administration of palliatives) are generally the fatal ones. When the child is convalescing, let him beware of stimulating food and overheated rooms. Do not give aperient medi-

cines; costiveness, as an after-effect of pleuritic affections, will soon yield to fresh air and a vegetable diet.

Worms.—Intestinal parasites are symptoms rather than a cause of defective digestion, and drastic medicines (calomel, Glauber's-salt, etc.) are merely palliatives; even a change of diet may fail to afford permanent relief if the general mode of life favors a costive condition of the bowels. Like maggots, maw-worms seem to thrive only on putrescent substances, on accumulated ingesta in a state of self-decomposition, and disappear as soon as exercise, cold fresh air, and a frugal diet have reëstablished the functional vigor of the digestive organs.

Diarrhœa.—An abnormal looseness of the bowels is an effort of Nature to rid the stomach of some irritating substance, and suggests the agency of a dietetic abuse, either in quantity or in quality. An excessive quantum even of the healthiest food will purge the bowels like a drastic poison, unless the alimentary wants—and consequently the assimilative abilities of the system—have been increased by active exercise. On the hunting-grounds of the upper Alps, an Austrian sportsman can assimilate a quantity of meat which the kitchen artists of the best Vienna restaurant could not have foisted upon the stomach of an indolent burgher. Dysentery medicines can be entirely dispensed with if one can get the patient to try the effect of Nature's two specifics—fasting and pedestrian exercise. Combined they will only fail when opiates have produced an inflammatory condition of the bowels, in which case a grape- or water-cure must precede the more radical remedies. The languor of dysentery is always combined with a fretful restlessness, and should not be mistaken for the exhaustion that calls for repose and food: the patient is safe if we can fatigue him into actual sleepiness, or anything like a genuine appetite; when the digestive organs announce the need of nourishment, they can be relied upon to find ways and means to retain it.

Constipation.—A slight stringency of the bowels should never be interfered with; in summer-time close stools are consistent with a good appetite and general bodily vigor. Aperient medicines provoke a morbid activity of the bowels, followed by a costiveness that differs from a summer constipation as insomnia differs from a transient sleeplessness. In England and the United States the use of laxative drugs has repeatedly become epidemic and in its consequences a true national misfortune;* and a sad majority of otherwise intelligent parents are still afflicted with the idea that children have to "take something"—in other words, that their bowels have to be convulsed with

* "If the bowels become constipated, they are dosed with pills, with black draughts, with brimstone and treacle, and medicines of that class, almost *ad infinitum*. Opening medicines, by constant repetition, lose their effects, and therefore require to be made stronger and stronger, until at length the strongest will scarcely act at all; . . . the patients become dull and listless, requiring daily doses of physic until they almost live on medicine."—(H. Chavasse, "Advice to a Mother," p. 388.)

poisons, for every trifling complaint. Constipation is often simply a transient lassitude of the system, a functional tardiness caused by fatigue and perspiration, and very apt to cure itself in the course of two or three days, especially at a change from a higher to a lower temperature. After the third day the disorder demands a change of regimen: cold ablutions, lighter bedclothes, in summer-time removal of the bed to the coolest and airiest available locality, and liberal rations of the most digestible food—bran-bread, sweet cold milk, stewed prunes, and fresh fruit in any desired quantity; *faute de mieux*, cold water and sugar, oatmeal-gruel, and diluted molasses. The legumina, in all their combinations, are likewise very efficient bowel regulators, and common pea-soup is a remedial equivalent of Du Barry's expensive "revalenta Arabica" (lentil-powder). For real dyspepsia (rarely a chronic disease of youngsters in their teens), there is hardly any help but rough out-door exercise, daily pedestrian exercise or out-door labor, continued for hours in all kinds of weather. The Graham starvation cure might bring relief in the course of time, but for one person with passive heroism enough to resist the continual cravings of an abnormal appetite, hundreds can muster the requisite resolution for an occasional active effort, which will gradually but perceptibly restore the vigor of the system. Drugs only change the form of the disease by turning a confirmed surfeit-habit into a still more obstinate and less commutable alcohol-habit; the vile mixtures sold under the name of "tonic" bitters have never benefited anybody but their proprietors and the rum-sellers, to whose army of victims the patent-medicine dispensaries serve as so many recruiting-offices.

Active exercise is also the only remedy for those *secret vices* whose causes are as often misunderstood as their consequences. The pathologists who ascribe precocious prurience to the effects of a stimulating diet seem to overlook the fact that the most continent nations of antiquity, the Scythians and ancient Germans, were as nearly exclusively carnivorous as our Indian hunting-tribes, the apathy of whose sexual instincts has been alleged in explanation of their gradual extinction.* For the same reason the gauchos of the tropical pampas are an unprolific race, while the Russian mujiks and the sluggish boyars of the Danubian principalities are as salacious as the inert (though frugivorous) natives of southern Italy. Independent of climate and diet, the continence or incontinence of the different nations, or different classes of any nation, bears an unmistakable proportion to the degree of their indolence. Lazy cities and small, thickly populated islands (Lesbos, Paphos, Cythera, Otaheite) have been most conspicuous for the absence of those virtues which the Grecian allegory ascribed to the goddess of the chase. The *menu* prescribed by the founders of the monastic orders was rather ultra-Grahamite in quality and quantity, yet neither barley-bread nor the frequent fasts to aid the

* Ludwig, "American Aborigines," p. 128.

minutio monachi could counteract the effects of deficient exercise; if we can believe the publicists of the Reformation, the *chronique scandaleuse* of Lesbos and Capri was far surpassed in the record of some mediæval convents—and not in the flagrant latitude of Italy alone (Robert Burton's "Anatomy of Melancholy," volume of miscellanies, pp. 449–451, quotations, etc.). Nor can we mistake the significance of the circumstance that sexual aberrations in the years of immaturity are almost exclusively the vice of male children, whose potential energies, with the same diet and the same general mode of life, find no adequate vent in an amount of active exercise nearly sufficient for the constitutional wants of the other sex. Moral lectures are sadly ineffectual in such cases, because, as Gotthold Lessing remarks, vicious passions pervert the constitution of the mind as effectually as they subvert that of the body—"the evil powers blindfold the victims of their altars." A frugal diet may subserve the work of reform, but the great specific is competitive gymnastics, the society and example of merry, manly, and adventurous companions. Crank-work gymnastics won't do; enlist the pride of the young Trimalchion, watch him at play, find out his special *forte*, no matter what—running, jumping, or throwing stones—and organize a sodality for the cultivation of that particular accomplishment. Beguile him into heroic efforts, offer prizes and champion-badges: as soon as manful exercises become a pleasure, unmanning indulgences will lose their attractions. The depressing after-effect of sensual excesses, the dreary reaction, is a chief incentive to the repetition of the vicious act, and the success of all reformatory measures depends at first upon the possibility of relieving this depression by healthful diversion, till, in the course of time, regained mental and bodily vigor will help the remedial tendency of Nature to neutralize the morbid inclination.

"*Rickets*" is a sign of general debility, owing to mal-nutrition during the years of rapid growth. The best physic for a rickety child is milk, bran-bread, and fruit; the best physician, the drill-master of the turner-hall. Rickety children are apt to be precocious, and till their backs are straightened up their books ought to be thrown aside. Knock-knees, bow-legs, "chicken-breasts," and round shoulders are all amenable to treatment, if the cure be begun in time—during the first three years of the teens, of all ages at once the most plastic and the most retentive of deep impressions.

For the cure of young *topers*, *smokers*, and *gluttons* I am persuaded that punishments are only of temporary avail, and homilies of no use whatever. The most glowing eloquence palls before the suasion of a vicious *penchant*. Here, too, the chances of saving the tempted depend upon the possibility of silencing the tempter—by outbidding his offer. Provide healthful diversions; the victims of the poison-habit yield to temptation when the reaction (following upon every morbid excitement) becomes intolerable. Relieve the strain of that

reaction by diverting sports; improvise hunting expeditions and mountain-excursions, or Olympic games; between exciting diversions and sound sleep the toper will forget his tipple, and every day thus gained will lessen the danger of a relapse.

It can not be denied that *poison-habits* (the opium-habit as well as "alcoholism") are to some degree hereditary. The children of confirmed inebriates should be carefully guarded, not only against objective temptations, but against the promptings of a peculiar disposition which I have found to be a (periodical) characteristic of their mental constitution. They lack that spontaneous gayety which constitutes the almost misfortune-proof happiness of normal children, and, without being positively peevish or melancholy, their spirits seem to be clouded by an apathy which yields only to strong external excitants. But healthful amusements and healthy food rarely fail to restore the tone of the mind, and, even before the age of puberty, the manifestations of a more buoyant temper will prove that the patient has outgrown the hereditary hebetude, and with it the need of artificial stimulation.

Chlorosis, or green-sickness, is a malignant form of that dyspeptic pallor and languor which one half of our city girls owe to their sedentary occupations in ill-ventilated rooms. The complaint is almost unknown in rural districts, and the best cure is a mountain-excursion, afoot or on horseback; the next best a course of "calisthenics," a plentiful and varying vegetable diet, fun, frequent baths, and plenty of sleep. "Tonic" drugs are sure to aggravate the evil. It is only too well known that a fit of nervous depression can be *momentarily* relieved by a cup of strong green tea. The stimulus goads the weary system into a spasm of morbid activity: the vital strength, sorely needed for a reconstructive process (one of whose phases was the nervous depression), has now to be used to repel a pernicious intruder; and this convulsion of the organism, in its effort to rid itself of the narcotic poison, is mistaken for a sign of returning vigor—the patient "feels so much better." But, as soon as the irritant has been eliminated, the vital energy—diminished now by the expulsive effort—has to resume the work of reconstruction under less favorable circumstances; the patient now "feels so much worse"—by just as much as the reaction following upon the morbid excitement has since increased the nervous depression. In the same way precisely a "tonic" medicine operates upon the exhausted organism, and in the same way its effect—a morbid and transient stimulation—is mistaken for a permanent invigoration.

Pulmonary consumption, in its early stages, is perhaps the most curable of all chronic diseases. The records of the dissecting-room prove that in numerous cases lungs, wasted to one half of their normal size, have been healed, and, after a perfect cicatrization of the tuberculous ulcers, have for years performed all the essential functions of

the sound organ. Still, the actual waste of tissue is never perfectly repaired, and fragmentary lungs, supplying the undiminished wants of the whole organism, must necessarily do double work, and will be less able to respond to the demands of an abnormal exigency. But the lungs of a young child of consumptive parents are sound, though very sensitive, and, if the climacteric of the first teens has been passed in safety, or without too serious damage, the problem becomes reduced to the work of preservation and invigoration: the all but intact lungs of the healthy child can be more perfectly redeemed than the rudimentary organs of the far-gone consumptive; the phthisical taint can be more entirely eliminated and the respiratory apparatus strengthened to the degree of becoming the most vigorous part of the organism. The poet Goethe, afflicted in his childhood with spitting of blood and other hectic symptoms, thus completely redeemed himself by a judicious system of self-culture. Chateaubriand, a child of consumptive parents, steeled his constitution by traveling and fasting, and reached his eightieth year. By a relapse into imprudent habits, the latent spark, which under such circumstances seems to defy the eliminative efforts of half a century, may at any time be fanned into life-consuming flames, but in ninety-nine out of a hundred cases it will be found that the first improvement followed upon a change from a sedentary to an out-door and active mode of life. Impure air is the original cause of pulmonary consumption ("pulmonary scrofula," as Dr. Haller used to call it), and out-door life the only radical cure. The first symptoms of consumption are not easy to distinguish from those transient affections of the upper air-passages which are undoubtedly due to long confinement in a vitiated atmosphere: hoarseness, and a dry, rasping cough, rapid pulse, and general lassitude. Spitting of blood and pains in the chest are more characteristic symptoms, but the crucial test is the degree in which the respiratory functions are accelerated by any unusual effort. A common catarrh will not prevent a man from running up-stairs or walking up-hill for minutes together, without anything like visible distress; subjected to the same test, a person whose lungs are studded with tubercles will pant like a swimmer after a long dive, and his pulse will rise from an average of 65 to 110 and even 140 beats per minute. Combined with a hectic flush of the face, night-sweats, or general emaciation, shortness of breath leaves no doubt that the person thus affected is in the first stage of pulmonary consumption. If the patient were my son, I should remove the windows of his bedroom, and make him pass his days in the open air—as a cow-boy or berry-gatherer, if he could do no better. In case the disease had reached its *deliquium* period, the stage of violent bowel-complaints, dropsical swellings, and utter prostration, it would be better to let the sufferer die in peace, but, as long as he were able to digest a frugal meal and walk two miles on level ground, I should begin the out-door cure at any time of the year, and stake my own life on the result. I

should provide him with clothing enough to defy the vicissitudes of the seasons, and keep him out-doors in all kinds of weather—walking, riding, or sitting; he would be safe: the fresh air would prevent the *progress* of the disease. But *improve* he could not without exercise. Increased exercise is the price of increased vigor. Running and walking steel the leg-sinews. In order to strengthen his wrist-joints a man must handle heavy weights. Almost any bodily exercise—but especially swinging, wood-chopping, carrying weights, and walking uphill—increases the action of the lungs, and thus gradually their functional vigor. Gymnastics that expand the chest facilitate the action of the respiratory organs, and have the collateral advantage of strengthening the sinews, and invigorating the system in general, by accelerating every function of the vital process. The exponents of the movement-cure give a long list of athletic evolutions, warranted to widen out the chest as infallibly as French-horn practice expands the cheeks. But the trouble with such machine-exercises is that they are almost sure to be discontinued as soon as they have relieved a momentary distress, and, as Dr. Pitcher remarks in his "Memoirs of the Osage Indians," the symptoms of consumption (caused by smoking and confinement in winter quarters) disappear during their annual buffalo-hunt, but reappear upon their return to the indolent life of the wigwam. The problem is to make out-door exercise pleasant enough to be permanently preferable to the *far niente* whose sweets seem especially tempting to consumptives. This purpose accomplished, the steady progress of convalescence is generally insured, for the differences of climate, latitude, and altitude, of age and previous habits, almost disappear before the advantages of an habitual out-door life over the healthiest in-door occupations.

A tubercular diathesis inherited from both parents need not be considered an insuperable obstacle to a successful issue of the cure. The family of my old colleague, Dr. G——, of Namur, adopted a young relative who had lost his parents and his only brother by febrile consumption, and was supposed to be in an advanced stage of the same disease. The Antwerp doctors had given him up, his complaint having reached the stage of night-sweats and hectic chills, and, though by no means resigned to the verdict of the medical tribunal, he had an unfortunate aversion to anything like rough physical exercise. But his uncle, having from personal experience a supreme faith in the efficacy of the open-air cure, set about to study the character of the youngster, and finally hit upon a plan which resulted in the proudest triumph of his professional career. Pierre was neither a sportsman nor much of an amateur naturalist, but he had a fair share of what our phrenologists call "constructiveness"—could whittle out ingenious toys and make useful garden-chairs from cudgels and scraps of old iron. That proved a sufficient base of operations. The doctor had no farm of his own, and the only real estate in the market was a lot of

poor old pastures on a sparsely wooded slope of the Ardennes. Of this pasture-land he bought some ten or twelve acres, including a hill-top with a few shade-trees and a fine view toward the valley of the Sambre. At the first opportunity one of Pierre's garden-chairs was sent up to the lookout point, but rain and rough usage soon reduced it to its component elements—scrap-iron and loose cudgels. Pierre volunteered to repair it, and was supplied with such a variety of material and tools that he made two more chairs, and while he was about it also a rustic round-table with a center-hole, corresponding to the diameter of one of the shade-trees. The hill was only two miles from town, and soon became a favorite evening resort of the G—— family; but the road was rather steep, and Mrs. G—— appealed to the ingenuity of her constructive nephew: could he not try and make a winding trail by knocking some of the rocks and bushes out of the way? Pierre tried, and his success, the uncle declared, proved him and intuitive engineer, the peer of Haussmann and Brunel. That new road had so increased the value of the old pasture that it would be worth while to put up a pavilion and make it a regular hill-top resort. The only drawback upon the advantage of its situation was the want of good drinking-water; but there was a sort of a spring in an adjoining pasture on the opposite slope of the ridge: would Pierre make an estimate of the number of bricks requisite to wall it up and keep the cattle from muddling it? The requisition proved an under-estimate, but Pierre made up the deficiency by collecting a lot of passably square stones. The water now became drinkable, and somehow the rumor got abroad that Pierre had *discovered* the spring, whereupon his uncle's neighbor urged him to exercise his talent for the benefit of his valley-meadow, in all but the want of water the best pasture in the parish. Pierre selected a spot where a lot of day-laborers were set to work and actually struck water—by digging deep enough. The gratitude of the farmer was almost too demonstrative for the modest lad, who, however, agreed with his uncle that a talent of that sort might make its possessor a public benefactor, and ought to be cultivated. Would Pierre undertake to locate a well on his uncle's hill-pasture, a little nearer to the lookout point? The brick-spring was too far down, and it would be so convenient to have water on one's own premises! Judging from analogies, the young hydrologist fixed upon a spot at the junction of two ravines, but too near the upper boundary of arboreal vegetation, and after digging down to a stratum of dry sandstone detritus, the workmen gave up the job in disgust. But Pierre himself would not yield his point, and offered to dig the well alone if they would give him time, and a boy to turn the windlass of the sand-bucket. His wish was granted, and before he had been a week at work, his asthma had left him, his digestion improved, and his appetite became ravenous. The well-project had finally to be relinquished, but his uncle consoled him by purchasing the adjoining lot and letting him

make a winding road from the brick-spring to the hill-top. The road was built, but Pierre indorsed the opinion of a professional engineer that the well-hole, too, would be full of water if the woods of the upper ridge had not been so ruthlessly destroyed and that the replanting of forest-trees along the line of the subterranean water-courses would not only replenish the springs but redeem the arid pastures of the foot-hills. The doctor controverted that point, but—just for the sake of experiment—procured a hundred beech-tree saplings, which Pierre planted and watered with untiring assiduity. Some sixty per cent. of the trees took root, to the unending astonishment of the uncle, who now declared that his confidence in the fertility of the ridge-land had increased to a degree which encouraged him to try his luck with orchard-trees. They procured a lot of young apple, almond, and apricot trees, about two hundred of each, and planted them along the line of the suppositive water-courses. Pierre superintended the work, and was kept so busy for the next eighteen months that he had no time to be sick for a single day. The boy that was given up by the Antwerp doctors is now a well-to-do horticulturist, able to climb without a stop the steepest ridge in the Ardennes and to fell a forty-years oak-tree in twenty minutes!

In the beginning of this chapter I have mentioned two forms of disease which, thus far, have not proved amenable to the hygienic (non-medicinal) mode of treatment, though it has already been ascertained that a mild vegetable demulcent—sarsaparilla, for instance—is as efficacious in those cases as the virulent mercurials of the old school. Antidotes and certain anodynes will, perhaps, also hold their own till we find a way of producing their effects by *mechanical* means. But, with these few exceptions, I will venture the prediction that, before the middle of the twentieth century, the internal use of drugs will be discarded by all intelligent physicians.

"If we reflect upon the obstinate health of animals and savages," says Dr. Schrodt, "upon the rapidity of their recovery from injuries that defy all the mixtures of materia medica; also upon the fact that the homœopathists cure their patients with milk-sugar and mummery, the prayer-Christians with mummery without milk-sugar, and my followers with a milk-diet without sugar or mummery—the conclusion forces itself upon us that the entire system of therapeutics is founded upon an erroneous view of disease."

And, moreover, I believe that the chief error can be accounted for: it is founded upon our erroneous view of the cause and cure of evil in general. Translated into plain speech, the foundation-principle of our system of ethics is this: that all natural things, especially our natural instincts, are essentially evil, and that salvation depends upon mysterious, anti-natural, and even supernatural remedies. This bottom-error has long biased all our physical and metaphysical theories. The use of our reasoning powers is naturally as agreeable as the exercise of

any other normal function: the anti-naturalists declared war against free inquiry, assured us that the study of logic and natural science is highly dangerous, and that the seeker after truth must content himself with the light of ghostly revelations. We have since ascertained that the ghosts are grossly ignorant of all terrestrial concernments, and that their reports on the supramundane state of affairs are, to say the least, suspiciously conflicting.

In all but the vilest creatures the love of freedom is as powerful as the instinct of self-preservation: the anti-naturalists inculcated the dogma of implicit submission to secular and spiritual authorities. The experiment was tried on the grandest scale, and the result has demonstrated that blind faith leads to idiocy, and that absolute monarchs must be absolutely abolished.

The testimony of our noses justifies the opinion that fresh air is preferable to prison-smells; the anti-naturalists informed us that at various seasons of the year, and every night, the out-door atmosphere becomes mortiferous, and that sleepers and invalids ought to be confined in air-tight apartments. We believed, till we found that the most implicit believers got rotten with scrofula.

Animals seem to live and thrive on the principle that palatable food recommends itself to the stomach, and that repulsive things ought to be avoided. The anti-naturalists reversed the maxim, and assured us that sweetmeats, uncooked vegetables, cold water, drunk when it tastes best—i. e., on a warm day—raw fruit, etc., are the causes of countless diseases, and that the execrable taste of a drug is not the least argument against its salubriousness. During the middle ages parents used to dose their children with brimstone and calomel, "to purify their blood," and, for the same purpose, the most nauseous mineral springs of every country are still pumped and bottled for the benefit of invalids. There is not a poison known to chemistry or botany but has been, and is still, daily prescribed as a health-giving substance, and, in the form of pills, drops, or powders, foisted upon a host of help-seeking invalids. But, since the revival of free inquiry, we have compared the statements of ancient historians and modern travelers, and it appears that the healthiest nations on earth have preserved their health on the principle that guides our dumb fellow-creatures, and would guide our children if they were permitted to follow their inclinations. An overwhelming testimony of facts has proved that the diseases of the human race can be cured easier without poison-drugs—easier in the very degree that would suggest the suspicion that every ounce of poison ever swallowed for remedial purposes has increased the weight of human misery.* And that same suspicion is forced upon us by

* "It is unnecessary for my present purpose to give a particular account of the results of homœopathy; . . . what I now claim with respect to it is, that a wise and beneficent Providence is using it to expose and break up a deep delusion. In the results of homœopathic practice, we have evidence in amount, and of a character sufficient, most incontestably

very cogent *a priori* reasons. If the testimony of our senses helps us to select our proper food, and warns us against injurious substances, have we any reason to suppose that such salutary intuitions forsake us at the time of the greatest need—in the hour of our struggle with a life-endangering disease? Shall we believe that at such times our sense of taste *warns us* against salubrious substances? And does it not urgently warn us against ninety-nine out of a hundred "medicines"? Shall the sick believe that an all-wise Creator has staked the chances of their recovery upon the accident of their acquaintance with Dr. Quack's Quinine Bitters or Puff & Co.'s Purgative Pills? Yet, is it possible to mistake the analogy between the remedial theories of our nostrum-mongers and the alleged moral "plan of salvation"? Is not the key-note of the Semitic dogma mistrust of our natural instincts and reliance upon abnormal remedies—mummeries, mysteries, and miracles?

Poison-mongers, physical or spiritual, will cease to be in request whenever their customers begin to suspect that this world of ours is governed by laws, and not by special acts of intervention; that sickness can be cured only by conformity to those laws, and not by drugs and prayers—i. e., anti natural and supernatural remedies. To the children of Nature all good things are attractive, all evil repulsive: the laws of God proclaim and avenge themselves; the Author of this logically-ordered universe can never have intended that our salvation should depend upon the accident of our acquaintance with the dogmas of an isolated act of revelation; and, as surely as the germ of the hidden seed-corn finds its way through night to light, the unaided instincts of the lowliest islander would guide him safely on the path of moral and physical welfare.

These words would be truisms if Truth had not been a contraband for the last eighteen hundred years: To nine tenths of our Christian contemporaries God's most authentic revelation is still a sealed book; and, before any reformer can hope to turn this chaos of vice, superstition, and quackery, into anything like a cosmos, he *must* convince his fellow-men that the study of Nature has to supersede the worship of miracles, even though that conviction should imply that the fundamental dogmas of our priest-religion are perniciously false.

to establish the fact that disease is a restorative operation, or renovating process, and that medicine has deceived us. The evidence is full and complete. It does not consist merely of a few isolated cases, whose recovery might be attributed to fortuitous circumstances, but it is a chain of testimony fortified by every possible circumstance. . . . All kinds and grades of disease have passed under the ordeal, and all classes and characters of persons have been concerned in the experiment as patients or witnesses; . . . *while the process of infinitesimally attenuating the drugs used was carried to such a ridiculous extent that no one will, on sober reflection, attribute any portion of the cure to the medicine.* I claim, then, that homœopathy may be regarded as a providential sealing of the fate of old medical views and practice."—(Isaac Jennings, M. D., "Medical Reform," p. 247.)

THE PRACTICAL BUSINESS OF LIFE INSURANCE.

By THEODORE WEHLE.

THE mortality tables, forming the theoretical basis of life insurance, having been explained, it remains to be shown how they are employed in practice. There is a fundamental difference between life and fire or marine insurance that must first be considered. The hazard attaching to a building or a ship may remain unchanged for a very long term of years, and the rate of premium once determined need not be altered. Such property is usually insured for one year at a time, and renewed as often as desirable. But the same methods can not be applied to human life. If the policy were to terminate annually, and a new examination could be demanded, many persons whose health had become impaired would be declined at the beginning of every new year. Then, as has been shown, from a very young age, upward, the rate of mortality constantly increases. That would necessitate a higher premium charge from year to year, so that, finally, a person who should be fortunate enough to reach the highest age of the table would have to pay one hundred per cent. for that one year. It requires no argument to prove such a system impracticable, and therefore the plan of fixing one uniform periodic premium for the whole term of the proposed insurance has been adopted.

The following table shows, in one column, the amount of *net* premium that must be paid at the beginning of every year to insure $1,000 for that year; and, in the other column, the equal *net* annual premium to insure for life.

By net premium is meant the amount calculated from a certain mortality table, and rate of interest, without any addition for expenses.

In all illustrations hereafter given the American Experience Table and four and a half per cent. interest will be employed, that being the official standard for the State of New York.

Age.	Net premium for one year.	Net annual premium for life.	Age.	Net premium for one year.	Net annual premium for life.
20	$7 47	$11 97	60	$25 54	$54 14
21	7 51	12 23	70	59 61	97 00
22	7 57	12 50	80	138 24	188 20
			90	434 96	494 33
30	8 06	15 34	94	820 22	836 69
40	9 37	21 30	95	956 93	956 93
50	13 19	32 49			

From this table it appears that, to insure $1,000 for one year at a time, it would cost $7.47 at age 20, and that the amount would have to be continually increased, until at age 90 it would be $434.96, while

the same purpose would be accomplished for an equal annual premium of $11.97. The somewhat larger expense in the earlier years of insurance avoids the necessity of enormous charges at the high ages.

The method of arriving at the equal annual premium is based upon very plain reasoning, and can be explained in a simple manner.

Let us assume, with the American Experience Table, that, out of 100,000 persons at age 10, there remain 847 living at age 90, and that they die, according to the table, as follows:

Age.	Number living.	Number of deaths.
90	847	385
91	462	246
92	216	137
93	79	58
94	21	18
95	3	3
	1,628	847

Were these 847 to form an association, based on the condition that the payments remain equal throughout, and be collected from the survivors at the beginning of each year, and that $1 be paid at the death of each member, there would be 1,628 contributions during the whole period, to provide for 847 death-claims. The requisite annual premium would therefore be $\frac{847}{1628}$ of a dollar, or $0.52027 (52+cents). Let us examine the working of this fund:

Age 90—living, 847 × ·52027 = contributions		$440 67	
	Death-claims	385 00	
	Balance		$55 67
Age 91—living, 462 × ·52027 = contributions		$240 37	
	Balance	55 67	
		$296 04	
	Death-claims	246 00	
	Balance		$50 04
Age 92—living, 216 × ·52027 = contributions		$112 38	
	Balance	50 04	
		$162 42	
	Death-claims	137 00	
	Balance		$25 42
Age 93—living, 79 × ·52027 = contributions		$41 10	
	Balance	25 42	
		$66 52	
	Death-claims	58 00	
	Balance		$8 52

Age 94—living, 21 × ·52027 =	contributions	$10 92	
	Balance	8 52	
		$19 44	
	Death-claims	18 00	
	Balance		$1 44
Age 95—living, 3 × ·52027 =	contributions	$1 56	
	Balance	1 44	
		$3 00	
	Death-claims	3 00	

One important element, however, the investment of money at interest, has been omitted in the above illustration, and will be introduced now. It has already been stated that premiums are payable at the beginning, while death-claims are due at the end, of the same year. To bring these different amounts and dates to a common basis we must determine the present value of each, at the age at which the insurance begins. Knowing, from the table, the amounts of the contributions and the number of deaths and the time at which they become due, it is to be ascertained what amount of money deposited at the beginning of the period, improved at compound interest, would be equivalent to the total of these sums.

The present value of $1 at the beginning of the year, at 4½ per cent. interest, is $0·9569; that is to say, $0·9569 invested at 4½ per cent. interest will amount to $1 at the end of the year. The present value of $1 for two years is $0·9157, for three years $0·8763; or these amounts, improved at 4½ per cent. compound interest, will become $1 by the end of these years.

Applying this principle to the class of 847 persons under consideration, and assuming each contribution and each death-claim to be $1, we need only multiply these by the present value corresponding to each year, bearing in mind that the living pay in advance, while the death-claims are due at the end of the year:

Age.	Living.		Deaths.	
90	847 × $1	= $847 00	385 × ·9569	= $368 41
91	462 × ·9569	= 442 10	246 × ·9157	= 225 26
92	216 × ·9157	= 197 79	137 × ·8763	= 120 05
93	79 × ·8763	= 69 23	58 × ·8386	= 48 64
94	21 × ·8386	= 17 61	18 × ·8025	= 14 44
95	3 × ·8025	= 2 41	3 × ·7679	= 2 30
		$1,576 14		$779 10

The above calculation shows the present value of the 1,628 contributions, at $1 each, to be $1,576.14, and the present value of the 847 death-claims to be $779.10; therefore, to meet these latter, the contributions need only be, instead of one dollar, $\frac{779.10}{1576.14}$ of one dollar, or $0·49432 (49 + cents). The item of interest has reduced the premium to $0·49432, when, without it, it would have been $0·52027.

Similarly to the annual premium, any other mode of payment may be determined; say, for instance, one single premium for life. At age 90 the present value of all future death-claims is $779.10, and there are 847 persons to provide for the same; therefore, each one must contribute $\frac{779.10}{847}$, or $0·91987 in advance, that being the one single premium for life.

The limits of a magazine article do not permit more extended illustrations, but the reader can readily reason out for himself how premiums, insuring for life in a limited number of payments, and various other adaptations in vogue, all based upon the same principles, may be arrived at.

Let us now apply the annual premium of $0·49432, as above ascertained, to the insurance fund, and follow its working to the end, computing interest at 4½ per cent.:

Age 90—Living..... 847 × ·49432 = $418 69 × 1·045 = $437 53
Death-claims at the end of the year, 385 00
Balance, $52 53

Age 91 " ..... 462 × ·49432 = $228 37
Balance on hand, 52 53
$280.90 × 1·045 = $293 55
Death-claims at the end of the year, 246 00
Balance, $47 55

Age 92 " ..... 216 × ·49432 = $106 77
Balance on hand, 47 55
$154 32 × 1·045 = $161 27
Death-claims at the end of the year, 137 00
Balance, $24 27

Age 93 " ..... 79 × ·49432 = $39 05
Balance on hand, 24 27
$63 32 × 1·045 = $66 18
Death-claims at the end of the year, 58 00
Balance, $8 18

Age 94 " ..... 21 × ·49432 = $10 38
Balance on hand, 8 18
$18 56 × 1·045 = $19 39
Death-claims at the end of the year, 18 00
Balance, $1 39

Age 95 " ..... 3 × ·49432 = $1 48
Balance on hand, 1 39
$2 87 × 1·045 = $3 00
Death-claims at the end of the year, 3 00

It will be observed that, at the end of every year, with the exception of the last one, an unexpended balance remains; dividing this by the number of survivors, we get the amount that applies to each individual living at that period. This is called the net valuation, or, more commonly, the reserve for each policy.

At the ages we have under consideration, the reserve would be as follows:

End of Year.	Living.	Balance.	Reserve for each.
90	462	$52 53	$0·11370
91	216	47 55	0·22014
92	79	24 27	0·30721
93	21	8 18	0·38952
94	3	1 39	0·46261
95	..	....	.....

While the reserve, as here given, is strictly correct in amount as well as in principle, other methods of calculation are employed in practice; but, for a simple explanation, the plan here adopted will probably serve better than any other. The difficulty has also been that the very high age of ninety had to be selected for the above illustrations, because every computation has to be carried to the end of the table, which would be very lengthy and tedious for a young age. But, the explanation having been given, a closer inspection of the reserves applying to age twenty will afford a broader insight into the subject:

Age 20—Net Annual Premium $11.97 per $1,000.

End of Year.	Death-rate, per cent.	Cost of insurance.	Reserve.
20	·780	$7 77	$4 74
21	·785	7 78	9 67
22	·790	7 79	14 82
30	·843	7 88	64 92
40	·979	8 27	155 80
44	1·083	8 63	203 05
45	1·116	8 75	215 94
50	1·378	9 83	286 56
60	2·669	14 65	451 27
70	6·199	23 33	623 60
94	85·714	47 17	944 97
95	100·000	00 00	1,000 00

From the above table it will be seen that the annual premium may be looked upon as consisting of two parts, one defraying the annual cost of insurance dependent upon the death-rate, the other put aside as a reserve fund. Up to a certain period the premium is larger than

the actual cost of insurance, but a time arrives when it does not suffice, and then a part of the interest on the reserve must contribute the difference. It will be noticed that the reserve grows constantly, so that by the end of the year 94 it is $944.97, and, with the annual premium of $11.97, due at the beginning of year 95, amounts to $956.94, which, invested at 4½ per cent. interest, will by the end of the year produce the sum of $1,000. Theoretically, then, there is no loss from a person dying according to the last year of the mortality table, because the whole amount of the sum insured has already accumulated under the reserve.

This reserve, too, may in a certain sense be said to have a twofold function: it not only provides for the future, but also annually reduces the amount at risk, whereby the cost of insurance becomes less than it would otherwise be. Thus, by the above table for the year 45, the cost of insurance is only $8.75, while the death-rate would amount to $11.16 per $1,000. The fact that the reserve has reached $215.94, and the amount at risk is only $784.06, reduces the cost from $11.16 to $8.75. For the year 94 the death-rate would amount to $857.14 per $1,000, while the cost of insurance is only $47.17, since the reserve has accumulated to $944.97, leaving but $55.03 at risk.

As a final illustration of the whole method take the reserve at the end of year 44, $203.05, add the annual premium of $11.97, being together $215.02, invest at 4½ per cent. interest, and it will amount to $224.69; deduct the cost of insurance, $8.75 (being the amount at risk $784.06 × 1·116 per cent., the death-rate), and the balance remaining, $215.94, is the reserve at the end of year 45.

But, however instructive these details, it may be well, to avoid confusion, to sum up the whole process in the statement that the annual premium is a device to collect a larger amount than the death-rate in the earlier years of insurance, and to use these over-payments, improved at compound interest, to meet the deficiencies which arise in later years. The premium and reserve are so nicely adjusted that they are strictly equitable for the living as well as the dying at every year of life.

The view of the reserve or net valuation here presented is distinctively American. It has been embodied in State legislation, and has an important bearing upon the question of surrender values, presently to be considered. There are other methods for determing the valuation, which take into account all future payments due, and all losses and expenses to be incurred to the end of the table; but these are questions beyond the scope of this article.

To the net premium of which we have treated, a certain percentage is added to defray expenses and to provide for contingencies; it is called *loading*, and together with the net premium constitutes what is known as gross or office premium. In mutual companies, the only ones that will be here considered, the loading is made higher than any

probable exigency will demand, so as to be absolutely safe. At fixed periods the amount collected, in excess of actual cost, is distributed among the contributing members. It is erroneously called "profits" or "dividends," when, in reality, it is only a return of unexpended assessments. When the system was new and untried, it was not thought prudent to make such restitution oftener than every five years. Gradually experience led to greater confidence, and competition introduced the practice of annual "dividends." These are principally derived from the higher rate of interest realized than the legal standard assumes, from a lower mortality than the table estimates, and from the excess of loading over actual expenses. Various ways of distributing this surplus have been in use, but the so-called "contribution plan," now universally adopted in the United States, is unquestionably the most equitable ever devised, as it returns to every member precisely his proportion of the over-payments. It may be best explained by an illustration.

Take a policy issued at 25, at an annual premium of $19.89, on which a cash dividend of $6.72 has been declared at the end of year 38. Assume the expenses applying to this policy to be equal to about 10 per cent. of the annual premium, the average rate of interest realized 5½ per cent., and the actual mortality experience to be 10 per cent. less than the table indicates, the account would then stand as follows:

Reserve at the end of year 37		$101 51
Gross premium $19.89 paid at beginning of year 38, being net premium		13 42
Loading	$6 47	
Less actual expenses incurred	1 99	
		4 48
		$119 41
Interest earned at 5½ per cent		6 57
		$125 98
Reserve at end of year 38	$111 74	
Cost of insurance according to table	$8 35	
Less saving by actual mortality (10 per cent.)	83	
	7 52	
		119 26
Return due on policy		$6 72

The same result may be shown in another way:

Legal reserve based on 4½ per cent. interest, actually earned 5½ per cent., being gain of 1 per cent. on $111.74	$1 12
Loading exceeds actual expenses	4 48
Interest on same at 5½ per cent	25
Actual mortality less than assumed	83
Interest on same at 5½ per cent	4
	$6 72

Of course, there may be other items of gain or loss besides those enumerated in the above illustration.

Most companies give policy-holders the option of either taking a cash return, or having the amount converted into a "reversionary dividend," payable with the policy; that is, simply to purchase insurance for a single premium. The above cash dividend of $6.72 would give a net reversionary dividend of $20.82 (the net single premium for $1.00 at age 39 being $0·32283); but of course some deduction must be made for expenses of management.

These reversionary additions form a very large item with old institutions, one leading company alone having over $25,000,000 in force.

Intimately connected with the reserves and dividends, and next in importance, is the question how lapsed or forfeited policies should be treated. Probably no theoretical point has been so hotly contested, and certainly none has offered equal difficulties in practice. In the early days of the institution, when it was prudent to err on the side of safety, the view prevailed that a policy was a contract for life, from which neither party could withdraw. Instead of a single premium in advance, annual account payments were accepted, but it was thought that a violation of this condition could only be regulated by absolute forfeiture of all previous contributions. As the business grew in importance, and long experience proved it grounded on reliable foundations, the harshness of this rule began to attract attention.

In England Dr. Farr advised the issuing of non-forfeitable policies, and the allowance of a definite cash surrender value on them. In this country the Insurance Commissioner of Massachusetts first brought the subject before the Legislature of that State, and a non-forfeiture law was passed in 1861. In opposition to the views held by actuaries of the old school, a tendency extreme in the other direction now began to assert itself. It was contended that the reserve pertaining to each policy should be considered equivalent to a deposit in a savings-bank, to be withdrawn at the pleasure of each individual insurer. This position was combated as wrong in theory, and as absolutely subversive of the business in practice. Insurance when applied to the individual becomes an absurdity, and it can only be safely conducted on averages dependent upon large aggregates. A person that insures for life virtually agrees to contribute to the death-claims of other members as long as he himself lives, and should he withdraw ought to pay his share of the liabilities assumed and the expenses of management attendant thereon. It becomes the duty of an insurance company to prevent the unnecessary withdrawal of its members, and self-preservation compels it to constantly strive to acquire new lives to retain the institution in a prosperous condition. Therefore, while it would be unjust to confiscate the whole accumulated reserve on lapsed policies,

it is but fair that such charge be made as to fully compensate the association for the loss of a withdrawing member.

These views may be considered as the equitable, middle course between two extreme positions, and they are now very generally conceded and adopted in practice. Policies are made non-forfeitable after two or three annual payments, and when lapsed, if presented within reasonable time, either paid-up insurance is granted or a percentage of the reserve allowed as cash surrender value. A few, indeed, have gone further, and printed in the contract the fixed cash surrender value that may be obtained at the end of every year. This innovation is not unlikely to be permanently ingrafted upon the business, and even now there is hardly a reputable company that declines to purchase its own policies when presented at the proper time; and the amounts thus expended are far greater than is generally known. One leading company of this State, whose annual premium income for 1879 was about $12,500,000, paid over $4,500,000 for surrendered policies. Various intricate formulas have been devised by actuaries to determine the strictly equitable surrender value, which, however, as far as the general reader is concerned, all culminate in a larger or smaller percentage of the reserve.

While proper agitation, competition, and a sense of justice, brought about a fair adjustment of cash surrender values, the question of paid-up insurance has been definitively determined in New York by the enactment of a statute, which went into effect January 1, 1880. It provides that when a policy shall lapse for the non-payment of premium, after being in force three years, the reserve and dividend additions on such policy shall, on demand made *within six months* after such lapse (unless the provisions of the statute had been specifically waived), be taken as a single premium at the published rates of the company, and be applied either to continue the policy in force at its *full amount*, so long as such single premium will purchase temporary insurance for that amount, or to purchase paid-up insurance, payable at the *same time* as the original insurance; provided, however, that the net value of the insurance given for such single premium shall in no case be less than two thirds of the entire reserve. That is to say, that the whole amount of the policy shall remain in force for such a length of time as no less than two thirds of the net reserve will purchase, or that the amount of the policy shall be reduced correspondingly, and be made to expire at the time originally fixed by the policy. In principle, therefore, the question may be considered as permanently settled, and new methods will certainly be devised to adjust minor practical difficulties upon an equitable basis.

Still, many crude ideas yet prevail among the insuring public, which lead to misunderstandings that ought not to exist. Some intelligent men, even, imagine that a company should be compelled to reinstate a lapsed policy without reëxamination of the insured life, or that, at

least, the whole amount of premiums paid ought to be returned, since no loss has occurred. However absurd such notions, they have caused much dissatisfaction, and, as they spring from a total misconception of the aims and functions of the institution, they ought to be dispelled. The companies themselves are not free from blame, however, for permitting many false impressions to gain ground. Nothing can be more mischievous than the assertion that life insurance is a profitable investment for money in the ordinary acceptation of that phrase. It is a provision against a contingency to which every human being is subject. A proper appreciation of its great benefits would prompt most men to seek its protection as far as their means permitted. To the majority of insurers, however, it is an actual expense, though allotted among them upon the most equitable basis. On the other hand, the amount of premiums paid can never be totally lost, since every life-policy must eventually become a death-claim. But only those should insure who really require it and can continue payments to the end. Had this always been understood, many policy-holders would have been spared disappointment and suffering when sober reaction followed a period of wild inflation.

One of the evils resulting from dissatisfaction with insurance companies has been the formation, all over the country, of so-called coöperative (latterly mutual benefit) life associations. They are based on what has already been shown as utterly impracticable—the collection of contributions on the death of members, with no fixed premiums or adequate accumulation of reserves. When the lives are newly selected, and not much above middle age, there is, at first, an appearance of saving over regular premiums. But, as they get older and the rate of mortality rises rapidly, the contributions become onerous, and, there being nothing to forfeit, the healthy lives withdraw, leaving a constantly increasing preponderance of impaired lives. The association breaks up, and those most in need of insurance can no longer obtain it from regular companies. The fallacy consists in assuming a continuous increase of new young lives that are willing to bear the burdens of the old members; an infatuation that never lasts long. It seems almost incredible that, in the face of well-established scientific principles and a century's experience, such crude experiments should again be introduced, as though they were a new invention. They deserve no better name than frauds, originated either by designing men to plunder the credulous or by those so grossly ignorant as to be no less culpable. Well have they merited the name current in insurance parlance, "the co-duperatives."

We have now touched upon most of the distinctive features of life insurance that interest the general reader, and but little remains to be said of the general management. It has been shown that next in importance to the collection of premiums is the accumulation of a reserve, which must earn at least the minimum rate of interest assumed as the

basis of calculation. This is no easy task in the present condition of the money market, and exceptional skill, prudence, and forethought, are required to secure safe and profitable investments. It must be remembered, too, that theoretically all the funds on hand are supposed to bring interest, while in practice a considerable part must always remain unemployed, so that the average rate realized is less than the current rate of interest. On the other hand, well-managed companies accumulate a surplus over the net reserve, and have their interest income largely increased from this source. Still more important is the fact, as far as New York is concerned, that, since Massachusetts and some other States have established four per cent. as the legal standard for reserve, and all companies desire to transact business in those States, they keep their surplus sufficiently high to be virtually on a four per cent. basis. Whether a lower rate than this will be realized on safe investments in the next quarter of a century, expert financiers and economists seem hardly prepared to answer; but, should a reduction to a three and a half per cent. standard become necessary, it would only temporarily incommode our sound offices.

With mortality tables as reliable as any human estimate can make them, and with reserves based on a sufficiently low rate of interest, the management of a life-insurance company does not materially differ from that of other moneyed institutions. The proper selection of business and the safe investment of funds require prudence and sagacity, and devolve great responsibility upon executive officers. But mutual-insurance companies (and nearly all stock companies in the United States also embody the mutual principle) have a margin far above any probable exigency, in the excessive loading of premiums. This very safeguard, it is true, may be perverted, and in some cases has been a temptation to abuse and extravagance. A life-insurance company once fairly established, however, ought to be as safe as any other financial institution, and, where failure occurs, it may always be traced to either gross mismanagement or intentional fraud. State supervision, which has been of great benefit to the system and to the community, can never supplant individual judgment or probity. In fact, it ought to be limited to prescribing minimum reserves, the character of investments, and the publication of truthful statements of the condition of companies.

While life insurance is of comparatively recent date in the United States (the oldest company now in business having been organized in 1843), its development has been so rapid as to have probably surpassed that of every other country. The following table shows the condition of the business, as reported to the New York department, in its infancy in 1859, its period of highest inflation in 1870, and at the lowest point of reaction in 1879:

1859.	No. of companies.	Number of policies.	Amount of insurance.	Gross assets.	Surplus.
New York State....	8	23,690	$72,197,426	$11,629,085	$3,630,706
Other States.....	6	25,918	69,300,541	8,907,000	1,440,442
	14	49,608	$141,497,967	$20,536,085	$5,071,148
1870.					
New York State....	41	377,437	$1,039,662,517	$133,119,187	$19,673,246
Other States.....	30	370,370	984,222,438	136,401,253	28,815,048
	71	747,807	$2,023,884,955	$269,520,440	$48,488,294
1879.					
New York State....	12	261,799	$730,648,500	$202,562,832	$32,887,465
Other States.....	19	333,687	709,312,665	198,952,961	32,390,256
	31	595,486	$1,439,961,165	$401,515,793	$65,277,721

The number of companies rose from fourteen to seventy-one in eleven years, and fell to thirty-one in the following nine years, while the amount insured was only reduced by about 25 per cent. Compared with other institutions, this shrinkage during a period of general retrenchment is not large. With about 600,000 policies in force, $400,000,000 of assets and $65,000,000 of net surplus, the success of life insurance is really astonishing. As a coöperative enterprise, in the truest sense of the word, it outranks every other in the means employed. Scientific principles are applied to the solution of an intricate social problem, and result in the most equitable division of burdens. The aims and purposes are most exalted, too. Other associations combine individuals to coöperate with a view to their own present support and immediate enjoyment, while this institution is based upon abstention, self-imposed for other future beneficiaries.

With its usefulness not yet fully appreciated, its wide field of application not thoroughly understood, we may well be thankful for what it has already accomplished, and be proud of it as an exponent of the civilization and of the times in which we live.

HOW THE EARTH IS WEIGHED.

By Dr. OTTO WALTERHÖFER.

EFFORTS have been made, at all times in which the spirit of investigation can be said to have existed, to ascertain the condition of the interior of the earth. There has been no lack of unfounded assumptions on the subject, and fanciful hypotheses were held even down to a period in which correct conclusions had been reached upon

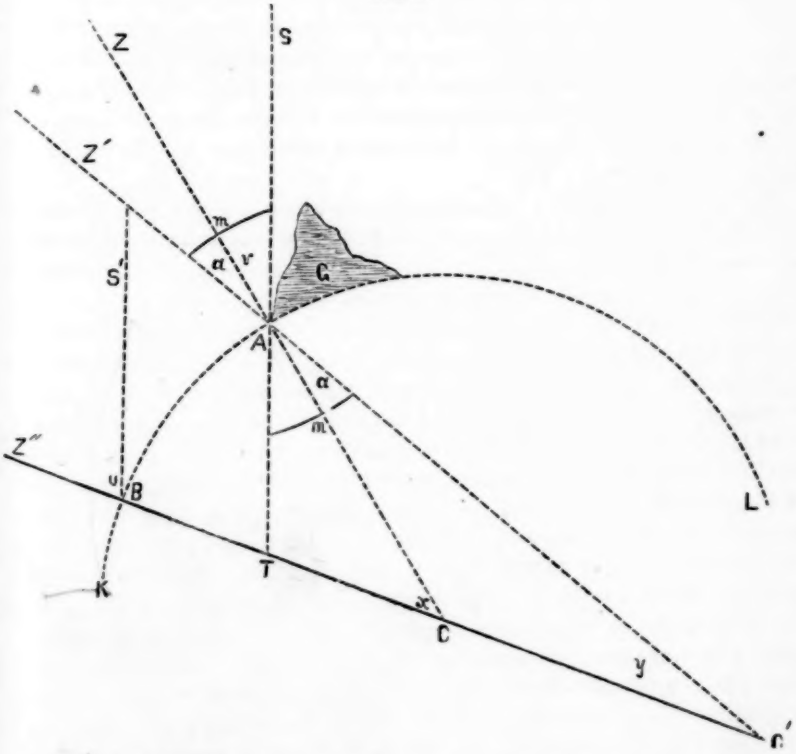
it—to the beginning of the nineteenth century. Alexander von Humboldt relates that he and Sir Humphry Davy were several times invited by Captain Symmes to join an expedition into the interior of the earth, which was represented as a hollow sphere having a large opening at the eighty-second parallel of north latitude. The idea of the existence of a hollow space within the earth was set at rest by the measurement of the average density of the planet, and the contrary view was advanced that the globe is a mass of great specific gravity. The constituency of this mass, whether it is fluid or solid, with only local bubble-like spaces, filled with fluid matter, has not been determined; but the calculations that have been made contradict the theory of a wholly fluid interior.

Several methods have been adopted for ascertaining the mean density of the earth, to the older of which a more accurate method has been added within a few years. An account of the methods hitherto adopted, and the results obtained by them, is here given.

DETERMINATION FROM THE DEFLECTION OF THE PLUMB-LINE.—Newton first suggested that the specific gravity of the earth could be ascertained by means of the plumb-line, but he made no effort to apply his suggestion. The thought was a sequence of his law of gravitation, on which all the methods that have been employed have been based. That law declares that all bodies exert an attractive force upon each other in direct proportion to their masses and in inverse proportion to the square of the distance of their centers of gravity from each other. Accordingly, a body hanging by a line, which over a level surface would be drawn by the earth's attraction into a direction with reference to its point of suspension, the prolongation of the line of which would pass through the center of the earth—that is, would be perpendicular, or plumb—would be attracted and turned away from the perpendicular by a mass like a mountain in the neighborhood. If, now, the amount of this diversion and the size of the mass exercising the deflecting influence were known, then the mass of the earth, and from this in connection with the shape and size of the earth, its mean density, could be computed. The diversion of the plummet from its perpendicular direction is, however, too minute to make a direct measurement possible, and the following method has, therefore, been adopted: In Fig. 1, let K L be a part of the surface of the earth, and G an isolated mountain. A plumb-line at the point A, at the foot of the mountain, and one at B, several miles from it, would take such directions in case the earth were a perfect sphere that the prolongation of the lines would intersect each other at the center of the earth, and form the angle x, with the sides C Z and C Z″, Z and Z″ representing the zeniths at A and B. The zenith-distance v, of any suitable fixed star S, in the neighborhood of Z, may be easily obtained by direct measurement. Let also the zenith-distance of the same star at the point B, which is equivalent to the angle u, be determined. The lines

A S and B S′, representing the direction of the star S, as seen from the points A and B, may, in consequence of the immense distance of the star from the earth, be regarded as parallel. On account of the proximity of the mountain G, the plumb-line does not take the direction

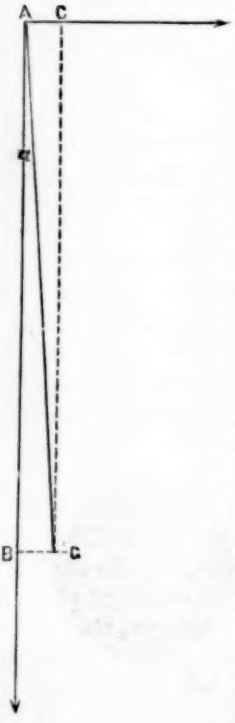
FIG. 1.



A Z, but is deflected toward the mountain, so that it gives the direction A Z′ as the apparent vertical, and Z′ as the apparent zenith. On this account, the zenith-distance of the star is increased by the angle a, to a degree that is represented by the angle m. The prolonged plumb-lines B Z″ and A Z′ consequently do not form the angle x at the center of the earth, but another angle, y, which differs from x by the magnitude a, wherefore, $a = x - y$. If, now, we imagine the line of direction A S prolonged backward, an equivalent of the angle u is formed at T, and by the lines A C′ and A T the angle m, equal to the observed zenith-distance at A. But u being the external angle of a triangle, $= m - y$, or $y = m - u$; and since a is equal to $x - y$, if we substitute for y the difference $m - u$, $a = x + u - m$. The angles u and m have been obtained by observation as zenith-distances of the fixed star S S′, and we have only to obtain the value of the angle x, which is deduced from a trigonometrical measurement of the arc A B. The mass of the

mountain which diverts the lead is found by a calculation of its form, magnitude, and density, and the mean density of the earth is afterward obtained by a calculation based upon the following data: Let A C (Fig. 2) represent the amount and direction of the attraction which the mountain exercises on the plummet, A B that of the earth upon the same; then A G represents the resultant attraction to which the lead is subjected. If, further, we make R represent the distance of the earth's center, and r that of the center of gravity of the mountain, from the lead, and M and m respectively, the masses of the earth and of the mountain, then we have, according to the law of attraction, $\frac{M}{R^2} : \frac{m}{r^2} :: A B : A C$, or since $A C = B G$, $\frac{M}{R^2} : \frac{m}{r^2} :: A B : B G$. From this proportion the mass and density of the earth are deduced by a series of mathematical formulas which it is not necessary to give in detail here.

FIG. 2.



Proceeding by this method, Maskelyne and Hutton undertook, between 1774 and 1776, the first efforts to estimate the specific gravity of the earth. They conducted their experiments near Mount Shehallien in Perthshire, Scotland, and found that the lead was deflected by the mountain to the amount of fifty-three seconds, whence they calculated the mean density of the earth to be 4·7. Making use of the observations of these two philosophers, Playfair and Seymour, after corrected calculations of the density of Shehallien, obtained a mean density of 4·7113.

Although no theoretical objections can be offered to the manner in which these observations were applied, great exactness can not be claimed for the results, because the calculations of the mass of the mountain, of its mean density, and of the distance of its center of gravity from the lead, were based on estimates, and liable to errors.

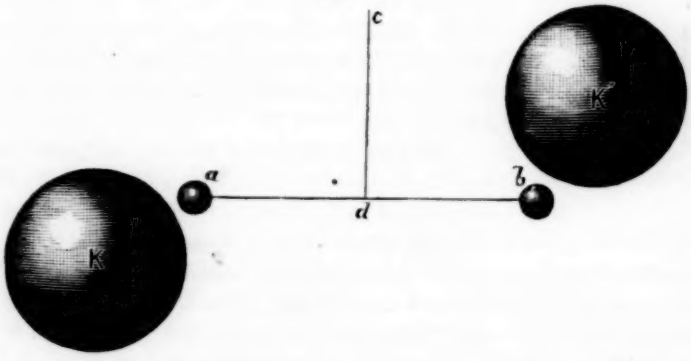
DETERMINATION BY MEANS OF THE PENDULUM.—A pendulum which is forced out of the vertical direction tends to resume it as soon as the deflecting force is removed. Its momentum carries it beyond the vertical position, and it therefore swings back and forth in times proportionate to its length. The durations of single oscillations of the same pendulum may be considered to be equal to each other if the departure from the vertical does not exceed five degrees. The cause of the oscillations is gravity, or the attractive power of the earth. Since this force diminishes as the square of the distance from the earth's center increases, its amount at different elevations above

the surface may be exactly calculated. The time required for the vibration of the pendulum is, in consequence of the same law, longer at heights above, shorter at points below the surface of the earth, than at the surface itself; hence it is easy to calculate the time of an oscillation at any given elevation. It is necessary, however, in order that the time calculated in this manner may agree with the result actually observed, that the surface of the earth at the given point shall be plane, and form part of an exact sphere. Mountains near the place of observation cause the attraction on the ball to be stronger than is contemplated in the calculation, and make the oscillations more rapid. The difference between the calculated and observed rate of oscillation will give the amount of influence which the mountain exerts. From this, the relative masses of the mountain and the earth being known, the mean density of the earth may be calculated by a series of formulas similar to those by which it is computed in the method just described. This method is liable to the same defects as the former one; that is, that the elements of the mountain on which the calculations are based are estimated, not accurately measured.

Carlini, Biot, and Matthieu employed it in 1824, Carlini selecting Mont Cenis as his point of observation, the other philosophers performing their experiments at Bordeaux. Their calculations gave a mean density of 4·83. Two other philosophers, Julius and E. Schmidt, calculating from the same observations, obtained, the former 4·95, the latter 4·84. Adopting a converse method from that of Carlini, Drobish, in 1826, measured the duration of the oscillations of the pendulum in a mining-shaft at Dolcoath, in Cornwall, and obtained 5·43.

Determination by Means of the Torsion Balance.—The torsion balance employed in measuring the density of the earth consists

Fig. 3.



of a straight rod *a b* (Fig. 3) of as uniform dimensions as possible, made of wood or metal, hanging by the cord *c d*, and supporting at its ends the balls *a* and *b*. A small mirror at *d*, in the middle of the

rod, on which a perpendicular beam of light is made to fall, indicates, by means of a graduated circle engraved upon it, the most minute horizontal deflections of the balance. Two leaden balls, *K* and *K'*, are brought within a suitable distance of the balls *a* and *b*, exercise an attractive force upon them, and cause an horizontal deflection of the balance, in a direction opposed to the torsion force of the cord, the value of which may be ascertained by measurement. From this value is computed the force of the attraction which the leaden masses *K* and *K'* exercise upon *a* and *b*. Since the masses of the four balls, their relative distances from each other, and the amount of the attraction exerted upon them by the earth (which is given by the absolute weight of the balls), are all measurable, the ratio of the mass of the earth to the masses of the balls *K* and *K'* can be calculated, and from this, by the process already given, the mean density of the earth.

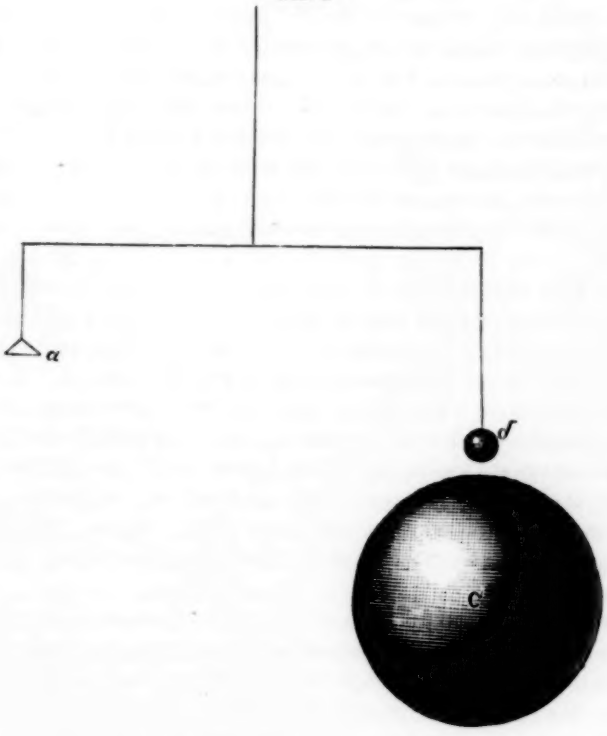
The results obtained by this method have a considerable degree of trustworthiness, for clear determinations are obtained in which errors are possible only in a small degree. The method was used by Cavendish in 1798, whose calculations gave 5·48, by Reich in Freiberg in 1837, who obtained 5·44, and by Baily in 1842, who obtained 5·6747. Reich repeated his experiments with improved apparatus between 1847 and 1850, using tin balls instead of leaden ones, and twisted copper wires or double iron wires instead of cord, and obtained 5·5756, a value which is often written briefly as 5·58. Hutton calculated the specific gravity of the earth from Cavendish's observations at 5·32, and E. Schmidt at 5.52.

Determination by Means of the Two-Armed Balance.—The idea of using the balance as means of measuring the mean density of the earth originated with the physicist Jolly, who suggested its application to this purpose in describing some improvements he had made in the instrument to increase its sensitiveness. The application was made by H. Poynting, in Manchester, who adopted the following method: Instead of a scale, he attached a weight (*b* Fig. 4), of 452·92 grammes to the end of a rod six feet in length, to which he opposed a counter-weight in the scale at the other end of the balance; a ball, *C*, weighing 154·220·6 grammes was brought to a position perpendicularly under *b*, when the mutual attraction of the two bodies occasioned a disturbance of the balance to the amount of 0·01 of a milligramme. The weight of the two mutually attracting bodies and the amount of attraction exerted upon them by the earth being known, and the distance apart of their centers of gravity having been carefully measured, Poynting calculated the mean density of our planet at 5·69, with a probable error of 0·15.

The approximate agreement of the results obtained by these four methods authorizes us to conclude that the masses of the interior of the earth possess a great density. If we consider, with Alexander von

Humboldt, that the dry continental parts of the crust of the earth have a mean density of from 2·4 to 2·6, and the dry and oceanic parts of 1·5, and accept Reich's later estimate of the mean total density at 5·58, then the inaccessible, internal parts of the earth must have a

FIG. 4.



mean specific weight of 9·66. Only the metals among the bodies in the accessible parts of the earth possess so great a density; we have a right, then, to believe that the nucleus of the earth possesses a metallic constitution.

The density of the other heavenly bodies is deduced from that of the earth, by observing the amount of attraction which two bodies exert upon each other, and upon a third, and, having ascertained the distances apart of the three bodies, calculating their mutual densities by approved mathematical formulas.—*Die Natur.*

THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

X.—THE MILITANT TYPE OF SOCIETY.

PRECEDING chapters have prepared the way for framing conceptions of the two fundamentally-unlike kinds of political organization, proper to the militant life and the industrial life, respectively. It will be instructive here to arrange in coherent order those traits of the militant type already incidentally marked, and to join with them various dependent traits; and in the next chapter to deal in like manner with the traits of the industrial type.

During social evolution there has habitually been a mingling of the two. But we shall find that, alike in theory and in fact, it is possible to trace out with due clearness those opposite characters which distinguish them in their respective complete developments. Especially is the essential nature of the organization which accompanies chronic militancy capable of being inferred *a priori*, and proved *a posteriori* to exist in numerous cases, while the essential nature of the organization accompanying pure industrialism, of which at present we have little experience, will be made clear by opposition, and such illustrations as exist of progress toward it will become recognizable.

In drawing conclusions, two liabilities to error must be guarded against. We have to deal with societies compounded and recompounded in various degrees; and we have to deal with societies which, differing in their stages of culture, have their organizations elaborated to different extents. We shall be misled, therefore, unless our comparisons are such as take account of unlikenesses in size and in civilization. Clearly, characteristics of the militant type which admit of being displayed by a vast nation may not admit of being displayed by a horde of savages, though this is equally militant. Moreover, as institutions take a long time to acquire their finished forms, it is not to be expected that all militant societies will display the structure appropriate to them in its completeness. Rather may we expect that in most cases it will be incompletely displayed.

In face of these difficulties the best course will be to consider, first, what are the several traits which of necessity militancy tends to produce; and then to observe how far these traits are conjointly shown in past and present nations distinguished by militancy. Having contemplated the society ideally organized for war, we shall be prepared to recognize in real societies the character which war has brought about.

For preserving its corporate life, a society is impelled to corporate action; and the preservation of its corporate life is the more probable

in proportion as its corporate action is the more complete. For purposes of offense and defense, the forces of individuals have to be combined; and, where every individual contributes his force, the probability of success is greatest. Numbers, natures, and circumstances being equal, it is clear that of two tribes or two larger societies, one of which unites the actions of all its capable members while the other does not, the first will ordinarily be the victor. There must be an habitual survival of communities in which militant coöperation is universal.

This proposition approaches very nearly to a truism. But it is needful here, as a preliminary, clearly to recognize the truth that the social structure evolved by chronic militancy is one in which all men fit for fighting act in concert against other societies. Such further actions as they carry on they can carry on separately; but this action they must carry on jointly.

A society's power of self-preservation will be great in proportion as, besides the direct aid of all who can fight, there is given the indirect aid of all who can not fight. Supposing them otherwise similar, those communities will survive in which the efforts of combatants are in the greatest degree seconded by those of non-combatants. In a purely militant society, therefore, individuals who do not bear arms have to spend their lives in furthering the maintenance of those who do. Whether, as happens at first, the non-combatants are exclusively the women; or whether, as happens later, the class includes enslaved captives; or whether, as happens later still, it includes serfs, the implication is the same. For, if, of two societies equal in other respects, the first wholly subordinates its workers in this way, while the workers in the second are allowed to retain for themselves the produce of their labor, or more of it than is needful for maintaining them, then, in the second, the warriors, not otherwise supported or supported less fully than they might else be, will have partially to support themselves, and will be so much the less available for war purposes. Hence, in the struggle for existence between such societies, it must usually happen that the first will vanquish the second. The type of society produced by survival of the fittest will be one in which the fighting part includes all who can bear arms and be trusted with arms, while the remaining part serves simply as a parmanent commissariat.

An obvious implication, of a significance to be hereafter pointed out, is that the non-combatant part, occupied in supporting the combatant part, can not with advantage to the self-preserving power of the society increase beyond the limit at which it efficiently fulfills its purpose. For, otherwise, some who might be fighters are superfluous workers; and the fighting power of the society is made less than it might be. Hence, in the militant type, the tendency is for the body of warriors to bear the largest practicable ratio to the body of workers.

Given two societies of which the members are all either warriors or those who supply the needs of warriors, and, other things equal, supremacy in war will be gained by that in which the efforts of all are most effectually combined. In open warfare joint action triumphs over individual action. Military history is a history of the successes of men trained to move and fight in concert.

Not only must there be in the fighting part a combination such that the powers of its units may be concentrated, but there must be a combination of the subservient part with it. If the two are so separated that they can act independently, the needs of the fighting part will not be adequately met. If to be cut off from a temporary base of operations is dangerous, still more dangerous is it to be cut off from the permanent base of operations—namely, that constituted by the body of non-combatants. This has to be so connected with the body of combatants that its services may be fully available. Evidently, therefore, development of the militant type involves a close binding of the society. As the loose group of savages yields to the solid phalanx, so, other things equal, must the society of which the parts are but feebly held together yield to one in which they are held together by strong bonds.

But, in proportion as men are compelled to coöperate, their self-prompted actions are restrained. By as much as the unit becomes merged in the mass, by so much does he lose his individuality as a unit. And this leads us to note the several ways in which evolution of the militant type entails subordination of the citizen.

His life is not his own, but is at the disposal of his society. So long as he remains capable of bearing arms he has no alternative but to fight when called upon; and, where militancy is extreme, he can not return as a vanquished man under penalty of death.

Of course with this there goes possession of such liberty only as military obligations allow. He is free to pursue his private ends only when the society has no need of him; and, when it has need of him, his actions from hour to hour must conform, not to his own will, but to the public will.

So, too, with his property. Whether, as in many cases, what he holds as private he so holds by permission only, or whether private ownership is recognized, it remains true that in the last resort he is obliged to surrender whatever is demanded for public use.

Briefly, then, under the militant type the individual is owned by the state. While preservation of the society is the primary end, preservation of each member is a secondary end—an end cared for chiefly as subserving the primary end.

Fulfillment of these requirements, that there shall be complete corporate action, that to this end the non-combatant part shall be

occupied in providing for the combatant part, that the entire aggregate shall be strongly bound together, and that the units composing it must have their individualities in life, liberty, and property, thereby subordinated, presupposes a coercive instrumentality. No such union for corporate action can be achieved without a powerful controlling agency. On remembering the fatal results caused by division of counsels in war, or by separation into factions in face of an enemy, we see that chronic militancy tends to develop a despotism; since, other things equal, those societies will habitually survive in which, by its aid, the corporate action is made more complete.

And this involves a system of centralization. The trait made familiar to us by an army, in which, under a commander-in-chief, there are secondary commanders over large masses, and under these tertiary ones over smaller masses, and so on down to the ultimate divisions, must characterize the social organization at large. A militant society must have a regulative structure of this kind, since otherwise its corporate action can not be made most effectual. Without such grades of governing centers diffused throughout the non-combatant part as well as the combatant part, the entire forces of the aggregate can not be promptly put forth. Unless the workers are under a control akin to that which the fighters are under, their indirect aid can not be insured in full amount and with due quickness.

And this is the form of a society characterized by *status*—a society, the members of which stand one toward another in successive grades of subordination. From the despot down to the slave, all are masters of those below and subjects of those above. The relation of the child to the father, of the father to some superior, and so on up to the absolute head, is one in which the individual of lower status is at the mercy of one of higher status.

Otherwise described, the process of militant organization is a process of regimentation, which, primarily taking place in the army, secondarily affects the whole community.

The first indication of this we trace in the fact everywhere visible, that the military head grows into a civil head—mostly at once, and, in exceptional cases, at last, if militancy continues. Beginning as leader in war he becomes ruler in peace; and such regulative policy as he pursues in one sphere, he pursues, so far as conditions permit, in the other. Being, as the non-combatant part is, a permanent commissariat, the principle of graduated subordination is extended to it. Its members come to be directed in a way like that in which the warriors are directed—not literally, since the dispersion of the one and the concentration of the other prevent exact parallelism; but, nevertheless, similarly in principle. Labor is carried on under coercive control; and supervision spreads everywhere.

To suppose that a despotic military head, carrying out daily the

inherited traditions of regimental control as the sole form of government known to him, will not impose on the producing classes a kindred control, is to suppose in him sentiments and ideas entirely foreign to his circumstances.

The nature of the militant form of government will be further elucidated on observing that it is both positively regulative and negatively regulative. It does not simply restrain; it also enforces. Besides telling the individual what he shall not do, it tells him what he shall do.

That the government of a fighting body is thus characterized needs no showing. Indeed, commands of the positive kind given to the soldier are more important than those of the negative kind: fighting is done under the one, while order is maintained under the other. But here it chiefly concerns us to note that not only the control of military life, but also the control of civil life, is, under the militant type of government, thus characterized. There are two ways in which the ruling power may deal with the private individual. It may simply limit his actions to those which he can carry on without aggression, direct or indirect, upon others; in which case its action is negatively regulative. Or, besides doing this, it may prescribe the how, and the where, and the when, of his daily actions; may force him to do various things which he would not spontaneously do; may direct in greater or less detail his mode of living; in which case its action is positively regulative. Under the militant type this positively regulative action is widespread and peremptory. The civilian is in a condition as much like that of the soldier as difference of occupation permits.

And this is another way of expressing the truth that the fundamental principle of the militant type is compulsory coöperation. While this is obviously the principle under which the members of the combatant body act, it no less certainly must be the principle acted upon throughout the non-combatant body, if military efficiency is to be great; since, otherwise, the aid which the non-combatant body has to furnish can not be insured.

That binding together by which the units of a militant society are made into an efficient fighting structure tends to fix the position of each in rank, in occupation, in locality.

In a graduated regulative organization there is resistance to change from a lower to a higher grade. Such change is made difficult by lack of the possessions needed for filling superior positions; and it is made difficult by the opposition of those who already fill them, and can hold inferiors down. Preventing intrusion from below, these transmit their respective places and ranks to their descendants; and, as the principle of inheritance becomes settled, the rigidity of the social structure becomes decided. Only where an "egalitarian despotism" reduces all

subjects to the same political status—a condition of decay rather than of development—does the converse state arise.

The principle of inheritance, becoming established in respect of the classes which militancy originates, and fixing the general functions of their members from generation to generation, tends eventually to fix also their special functions. Not only do men of the slave classes and the artisan classes succeed to their respective positions, but they succeed to the particular occupations carried on in them. This, which is a working out of the tendency toward regimentation, is ascribable primarily to the fact that superiors, requiring from each kind of worker his particular product, have an interest in replacing him at death by a capable successor; while he, prompted to get aid in fulfilling of his tasks, has an interest in bringing up a son to his own occupation: the will of the son being powerless against these conspiring interests. Under the system of compulsory coöperation, therefore, the principle of inheritance, spreading through the producing organization, causes a relative rigidity in this also.

And then a kindred effect is shown in the entailed restraints on movement from place to place. In proportion as the individual is subordinated in life, liberty, and property, to his society, it is needful that his whereabout shall be constantly known. Obviously the relation of the soldier to his officer, and of this officer to his superior, is such that each must be ever at hand; and where the militant type is fully developed the like holds throughout the society. The slave can not leave his appointed abode; the serf is tied to his allotment; the master is not allowed to absent himself from his locality without leave.

So that the corporate action, the combination, the cohesion, the regimentation, which efficient militancy necessitates, imply a structure which strongly resists change.

A further trait of the militant type, naturally accompanying the last, is that organizations other than those forming parts of the state organization are wholly or partially repressed. The public combination occupying all fields, excludes private combinations.

For the achievement of complete corporate action, there must, as we have seen, be a centralized administration, not only throughout the combatant part, but throughout the non-combatant part; and, if there exist unions of citizens which act independently, they in so far diminish the range of this centralized administration. Any structures which are not parts of the state structure serve more or less as limitations to it, and stand in the way of the required unlimited subordination. If private combinations are allowed to exist, it will be on condition of submitting to an official regulation such as greatly restrains independent action; and since private combinations thus officially regulated are inevitably hindered from doing things not conforming to established routine, and are so debarred from improvement,

they can not habitually thrive and grow. Obviously, indeed, such combinations, formed on the principle of voluntary coöperation, are incongruous with the social type formed on the principle of compulsory coöperation. Hence the militant type is characterized by the absence, or comparative rarity, of bodies of citizens associated for commercial purposes, for propagating special religious views, for achieving philanthropic ends, etc.

Private combinations of one kind, however, are congruous with the militant type—the combinations, namely, which are formed for minor defensive or offensive purposes. We have, as examples, those which constitute factions, very general in militant societies; those which assume forms like the primitive guilds, serving for mutual protection; and those which take the shape of secret societies. Of such bodies it may be noted that they fulfill on a small scale ends like those which the whole society fulfills on a large scale—the ends of self-preservation, or aggression, or both. And it may be further noted that these small included societies are organized on the same principle as the large including society—the principle of compulsory coöperation. Their governments are coercive: in some cases even to the extent of killing those of their members who are disobedient.

A remaining fact to be noted is that a society of the militant type tends to evolve a self-sufficient sustaining organization. With its political autonomy there goes what we may call an economic autonomy. Evidently in proportion as it carries on frequent hostilities with surrounding societies, its commercial intercourse with them must be hindered or prevented: exchange of commodities can go on but to a slight extent between those who are continually fighting. A militant society must, therefore, to the greatest degree practicable, provide internally the supplies of all articles needful for carrying on the lives of its members. Such an economic state as that which existed during early feudal times, when, as in France, "the castles made almost all the articles used in them," is a state evidently entailed on groups, small or large, which are in constant antagonism with surrounding groups. If there does not already exist, within any group so circumstanced, an agency for producing some necessary article, inability to obtain it from without will lead to the establishment of an agency for obtaining it within.

Whence it follows that the desire "not to be dependent on foreigners" is one appropriate to the militant type of society. So long as there is danger that the supplies of needful things derived from other countries will be cut off by the breaking out of hostilities, it is imperative that there shall be maintained a power of producing these supplies at home, and that to this end the required structures shall be maintained. Hence there is a manifest direct relation between militant activities and a protectionist policy.

And now having noted the traits which may be expected to establish themselves by survival of the fittest during the struggle for existence among societies, let us observe how these traits are displayed in actual societies, similar in respect of their militancy but otherwise dissimilar.

Of course in small primitive groups, however warlike they may be, we must not look for more than rude outlines of the structure proper to the militant type. Being loosely aggregated, definite arrangement of their parts can be carried but to a small extent. Still, so far as it goes, the evidence is to the point. The fact that habitually the fighting body is coextensive with the adult male population is so familiar that no illustrations are needed. An equally familiar fact is that the women, occupying a servile position, do all the unskilled labor and bear the burdens; with which may be joined the fact that not unfrequently during war they carry the supplies, as in Asia among the Bhils and Khonds, as in Polynesia among the New Caledonians and Sandwich-Islanders, as in America among the Comanches, Mundrucus, Patagonians: their office as forming the permanent commissariat being thus clearly shown. We see, too, that, where the enslaving of captives has arisen, these also serve to support and aid the combatant class; acting during peace as producers and during war joining the women in attendance on the army, as among the New-Zealanders, or, as among the Malagasy, being then exclusively the carriers of provisions, etc. Again, in these first stages, as in later stages, we are shown that private claims are, in the militant type, overridden by public claims. The life of each man is held subject to the needs of the group; and, by implication, his freedom of action is similarly held. So, too, with his goods; as instance the remark made of the Brazilian Indians, that personal property, recognized but to a limited extent during peace, is scarcely at all recognized during war; and as instance Hearne's statement concerning certain hyperborean tribes of North America when about to make war, that "property of every kind that could be of general use now ceased to be private." To which add the cardinal truth, once more to be repeated, that where no political subordination exists war initiates it. Tacitly or overtly a chief is temporarily acknowledged; and he gains permanent power if war continues. From these beginnings of the militant type which small groups show us, let us pass to its developed forms as shown in larger groups.

"The army, or, what is nearly synonymous, the nation of Dahomey," to quote Burton's words, furnishes us with a good example: the excessive militancy being indicated by the fact that the royal bedroom is paved with skulls of enemies. Here the king is absolute, and is regarded as supernatural in character—he is "the spirit"; and of course he is the religious head—he ordains the priests. He absorbs in himself all powers and all rights: "by the state law of Dahomey. . . all men are slaves to the king." He "is heir to all his subjects"; and

he takes from living subjects whatever he likes. When we add that there is a frequent killing of victims to carry messages to the other world, as well as occasions on which numbers are sacrificed to supply deceased kings with attendants, we are shown that life, liberty, and property are at the entire disposal of the state as represented by its head. In both the civil and military organizations the centers and subcenters of control are numerous. Names, very generally given by the king and replacing surnames, change "with every rank of the holder"; and so detailed is the regimentation that "the dignities seem interminable." There are numerous sumptuary laws; and, according to Waitz, no one wears any other clothing or weapons than what the king gives him or allows him. Under penalty of slavery or death "no man must alter the construction of his house, sit upon a chair, or be carried on a hammock, or drink out of a glass," without permission of the king.

The ancient Peruvian empire, gradually established by the conquering Incas, may next be instanced. Here the ruler, divinely descended, sacred, absolute, was the center of a system which minutely controlled all life. His headship was at once military, political, ecclesiastical, judicial; and the entire nation was composed of those who, in the capacity of soldiers, laborers, and officials, were slaves to him and his deified ancestors. Military service was obligatory on all taxable Indians who were capable; and those of them who had served their prescribed terms, formed into reserves, had then to work under state superintendence. The army having heads of ten, fifty, a hundred, five hundred, a thousand, ten thousand, had, besides these, its superior commanders of Inca blood. The community at large was subject to a parallel regimentation: the inhabitants, registered in groups, being under the control of officers over tens, fifties, hundreds, and so on. And through these successive grades of centers reports ascended to the Inca governors of great divisions, passing on from them to the Inca; while his orders descended "from rank to rank till they reached the lowest." There was an ecclesiastical organization, similarly elaborate, having, for example, five classes of diviners; and there was an organization of spies to examine and report upon the doings of the other officers. Everything was under public inspection. There were village officers who overlooked the plowing, sowing, and harvesting. When there was a deficiency of rain, measured quantities of water were supplied by the state. Any who traveled without authority were punished as vagabonds; but, for those who were authorized to travel for public purposes, there were establishments supplying lodging and necessaries. "It was the duty of the decurions to see that the people were clothed"; and the kinds of cloth, decorations, badges, etc., to be worn by the different ranks were all prescribed. Besides this regulation of external life, there was regulation of domestic life. The people were required to "dine and sup with open doors, that the judges

might be able to enter freely"; and these judges had to see that the house, clothes, furniture, etc., were kept clean and in order, and the children properly disciplined: those who mismanaged their houses being flogged. Subject to this regulation, the people labored to support this elaborate state organization. The political, religious, and military classes, throughout all their grades, were exempt from tribute, while the laboring classes, when not serving in the army, had to yield up all produce beyond that required for their bare sustenance. Of the whole empire, one third was allotted for supporting the state, one third for supporting the prisethood, who ministered to the manes of ancestors, and the remaining third had to support the workers. Besides giving tribute by tilling the lands of the sun and the king, the workers had to till the lands of the soldiers on duty, as well as those of the incapables. And they had also to pay tribute of clothes, shoes, and arms. Of the lands on which the people maintained themselves, the parts were apportioned to each man according to the size of his family. Similarly with the produce of the flocks. Such moiety of this in each district as was not required for supplying public needs was periodically shorn, and the wool divided by officials. These arrangements were in pursuance of the principle that "the private property of each man was held by favor of the Inca, and according to their laws he had no other title to it." Thus the people, completely possessed by the state in person, property, and labor, transplanted to this or that locality, as the Inca directed, and, when not serving in the army, living under a discipline like that within the army, were units in a centralized regimented machine, moved throughout life to the greatest practicable extent by the Inca's will, and to the least practicable extent by their own wills. And, naturally, along with militant organization thus carried to its ideal limit, there went an almost entire absence of any other organization. They had no money; "they neither sold clothes nor houses nor estates"; and trade was represented among them by scarcely anything more than some bartering of articles of food.

So far as accounts of it go, ancient Egypt presents us with phenomena allied in their general if not in their special characters. Its predominant militancy during its remotest unrecorded times is sufficiently implied by the vast population of slaves who toiled to build the pyramids; and its subsequent continued militancy we are shown alike by the boasting records of its kings, and the delineations of their triumphs on its temple-walls. Along with this form of activity we have, as before, the god-descended ruler, limited in his powers only by the usages transmitted from his divine ancestors, who was at once political head, high-priest, commander-in-chief, and supreme judge. Under him was a centralized organization, of which the civil part was arranged in classes and sub-classes as definite as were those of the militant part. Of the four great social divisions—priests, soldiers, townsmen, or traders, and common people, beneath whom came the slaves—

the first contained more than a score of different orders; the second some half-dozen beyond those constituted by military grades; the third nearly a dozen; and the fourth a still greater number. Though within the ruling classes the castes were not so rigorously defined as to prevent change of function in successive generations, yet Herodotus and Diodorus state that industrial occupations descended from father to son; "every particular trade and manufacture was carried on by its own craftsmen, and none changed from one trade to another." How elaborate was the regimentation may be judged from the detailed account of the staff of officers and workers engaged in one of their vast quarries: the numbers and kinds of functionaries paralleling those of an army. To support this highly-developed regulative organization, civil, military, and sacerdotal—an organization which held exclusive possession of the land—the lower classes labored. "Overseers were set over the wretched people, who were urged to hard work more by the punishment of the stick than words of warning." And whether or not official oversight included domiciliary visits, it at any rate went to the extent of taking note of each family. "Every man was required under pain of death to give an account to the magistrate of how he earned his livelihood."

Take now another ancient society, which, contrasted in sundry respects, shows us, along with habitual militancy, the assumption of structural traits allied in their fundamental characters to those thus far observed. I refer to Sparta. That warfare did not among the Spartans evolve a simple despotic head, while in part due to causes which, as before shown, favor the development of compound political heads, was largely due to the accident of their double kingship: the presence of two divinely-descended chiefs prevented the concentration of power. But though from this cause there continued an imperfectly centralized government, the relation of this government to members of the community was substantially like that of militant governments in general. Notwithstanding the serfdom, and in towns the slavery of the Helots, and notwithstanding the political subordination of the Periœki, they all, in common with the Spartans proper, were under obligation to military service: the working function of the first, and the trading function, so far as it existed, which was carried on by the second, were subordinate to the militant function with which the third was exclusively occupied. And the civil divisions thus marked reappeared in the military divisions: "At the battle of Platæa every Spartan hoplite had seven Helots, and every Periœki hoplite one Helot to attend him." The extent to which, by the daily military discipline, prescribed military mess, and fixed contributions of food, the individual life of the Spartan was subordinated to the public demands from seven years upward, needs mention only to show the rigidity of the restraints which here, as elsewhere, the militant type imposes—restraints which were further shown in the prescribed age for marriage, the prevention

of domestic life, the forbidding of industry or any money-seeking occupation, the interdict of going abroad without leave, and the authorized censorship under which his days and nights were passed. There was fully carried out in Sparta the Greek theory of society, that "the citizen belongs neither to himself nor to his family, but to his city." So that though in this exceptional case chronic militancy was prevented from developing a supreme head, owning the individual citizen in body and estate, yet it developed an essentially identical relation between the community as a whole and its units. The community, exercising its power through a compound head instead of through a simple head, completely enslaved the individual. While the lives and labors of the Helots were devoted exclusively to the support of those who formed the militant organization, the lives and labors of those who formed the militant organization were exclusively devoted to the service of the state—they were slaves with a difference.

Of modern illustrations that furnished by Russia will suffice. Here, again, with the wars which effected conquests and consolidations, came the development of the victorious commander into the absolute ruler, who, if not divine by alleged origin, yet acquired something like divine *prestige*. "All men are equal before God, and the Russian's God is the Emperor," says De Custine; "the supreme governor is so raised above earth that he sees no difference between the serf and the lord." Under the stress of Peter the Great's wars, which, as the nobles complained, took them away from their homes, "not, as formerly, for a single campaign, but for long years," they became "the servants of the state, without privileges, without dignity, subjected to corporal punishment, and burdened with onerous duties from which there was no escape. . . . Any noble who refused to serve ('the state in the army, the fleet, or the civil administration, from boyhood to old age') was not only deprived of his estate, as in the old times, but was declared to be a traitor, and might be condemned to capital punishment." "Under Peter," says Wallace, "all offices, civil and military," were "arranged in fourteen classes or ranks"; and he "defined the obligations of each with microscopic minuteness. After his death the work was carried on in the same spirit, and the tendency reached its climax in the reign of Nicholas." In the words of De Custine, "the tchinn [the name for this organization] is a nation formed into a regiment; it is the military system applied to all classes of society, even to those who never go to war." With this universal regimentation in structure went a regimental discipline. The conduct of life was dictated to the citizens at large in the same way as to soldiers. In the reign of Peter and his successors domestic entertainments were appointed and regulated; the people were compelled to change their costumes; the clergy to cut off their beards; and even the harnessing of horses was according to pattern. Occupations were controlled to the extent that "no boyard could enter any profession, or forsake it

when embraced, or retire from public to private life, or dispose of his property, or travel into any foreign country, without tbe permission of the Czar." This omnipresent rule is well expressed in the close of certain rhymes, for which a military officer was sent to Siberia:

> "Tout se fait par ukase ici;
> C'est par ukase que l'on voyage,
> C'est par ukase que l'on rit."

Taking thus the existing barbarous society of Dahomey, formed of negroes; the extinct semi-civilized empire of the Incas, whose subjects were remote in blood from these; the ancient Egyptian empire peopled by yet other races; the community of the Spartans, again unlike in the type of its men; and the existing Russian nation made up of Slavs and Tartars—we have before us cases in which such similarities of social structure as exist can not be ascribed to inheritance of a common character by the social units. The immense contrasts between the populations of these several societies, too, varying from millions at the one extreme to thousands at the other, negative the supposition that their common structural traits are consequent on size. Nor can it be supposed that likenesses of conditions in respect of climate, surface, soil, flora, fauna, or likenesses of habits caused by such conditions, can have had anything to do with the likenesses of organization in these societies; for their respective habitats present numerous marked unlikenesses. Such traits as they one and all exhibit, not ascribable to any other cause, must thus be ascribed to the habitual militancy characteristic of them all. The results of induction alone would go far to warrant this ascription; and it is fully warranted by their correspondence with the results of deduction, as set forth above.

Any remaining doubts must disappear on observing how continued militancy is followed by further development of the militant organization. Three illustrations will suffice:

When, during Roman conquests, the tendency for the successful general to become despot, repeatedly displayed, finally took effect—when the title *imperator*, military in its primary meaning, became the title for the civil ruler, showing us on a higher platform that genesis of political headship out of military headship visible from the beginning—when, as usually happens, an increasingly-divine character was acquired by the civil ruler, as shown in the assumption of the sacred name Augustus, as well as in the growth of an actual worship of him; there simultaneously became more pronounced those further traits which characterize the militant type in its developed form. Practically, if not nominally, the other powers of the state were absorbed by him. In the words of Duruy, he had—

> the right of proposing, that is, of making, laws; of receiving and trying appeals, i. e., the supreme jurisdiction; of arresting by the tribunitian veto

every measure and every sentence, i. e., of putting his will in opposition to the laws and magistrates; of summoning the senate or the people, and presiding over it, i. e., of directing the electoral assemblages as he thought fit. And these prerogatives he will have not for a single year, but for life; not in Rome only . . . but throughout the empire; not shared with ten colleagues, but exercised by himself alone; lastly, without any account to render, since he never resigns his office.

Along with these changes went an increase in the number and definiteness of social divisions. The Emperor

placed between himself and the masses a multitude of people regularly classed by categories, and piled one above the other in such a way that this hierarchy, pressing with all its weight upon the masses underneath, held the people and factious individuals powerless. What remained of the old patrician nobility had the foremost rank in the city; . . . below it came the senatorial nobility, half hereditary; below that the moneyed nobility, or equestrian order—three aristocracies superposed. . . . The sons of senators formed a class intermediate between the senatorial and the equestrian order. . . . In the second century the senatorial families formed an hereditary nobility with privileges.

At the same time the administrative organization was greatly extended and complicated.

Augustus created a large number of new offices, as the superintendence of public works, roads, aqueducts, the Tiber-bed, distribution of corn to the people. . . . He also created numerous offices of procurators for the financial administration of the empire, and in Rome there were one thousand and sixty municipal officers.

The structural character proper to an army spread in a double way: military officers acquired civil functions and functionaries of a civil kind became partially military. The magistrates appointed by the Emperor, tending to replace those appointed by the people, had, along with their civil authority, military authority; and while "under Augustus the prefects of the pretorium were only military chiefs, . . . they gradually possessed themselves of the whole civil authority, and finally became, after the Emperor, the first personages in the empire." Moreover, the governmental structures grew by incorporating bodies of functionaries who were before independent. "In his ardor to organize everything, he aimed at regimenting the law itself, and made an official magistracy of that which had always been a free profession." To enforce the rule of this extended administration, the army was made permanent, and subjected to severe discipline. With the continued growth of the regulating and coercing organization, the drafts on producers increased; and, as was shown by extracts in a previous chapter concerning the Roman *régime* in Egypt and in Gaul, the working part of the community was reduced more and more to the form of a permanent commissariat. In Italy the condition eventually arrived at was one in which vast tracts were "intrusted to freedmen, whose only consideration was how to cultivate the land with the least

possible expense, and how to extract from their laborers the greatest amount of work with the smallest quantity of food."

An example under our immediate observation may next be taken —that of the German Empire. Such traits of the militant type in Germany as were before manifest have, since the late war, become still more manifest. The army, active and passive, including officers and attached functionaries, has been increased by about one hundred thousand men; and changes in 1875 and 1880, making certain reserves more available, have practically caused a further increase of like amount. Moreover, the smaller German states, having in great part surrendered the administration of their several contingents, the German army has become more consolidated; and even the armies of Saxony, Würtemberg, and Bavaria, being subject to imperial supervision, have in so far ceased to be independent. Instead of each year granting military supplies, as had been the practice in Prussia before the formation of the North-German Confederation, the Parliament of the empire was, in 1871, induced to vote the required annual sum for three years thereafter; in 1874 it did the like for the succeeding seven years; and again in 1880 the greatly increased amount for the augmented army was authorized for the seven years following—steps obviously surrendering popular checks on imperial power. Simultaneously, military officialism has been in two ways replacing civil officialism. Subaltern officers are rewarded for long services by appointments to civil posts—local communes being forced to give them the preference to civilians; and not a few members of the higher civil service, and of the universities, as well as teachers in the public schools, having served as "volunteers of one year," become commissioned officers of the Landwehr. During the stuggles of the so-called Kulturkampf, the ecclesiastical organization became more subordinated by the political. Priests suspended by bishops were maintained in their offices; it was made penal for a clergyman publicly to take part against the government; a recalcitrant bishop had his salary stopped; the curriculum for ecclesiastics was prescribed by the state, and examination by state officials required; church discipline was subjected to state approval; and a power of expelling rebellious clergy from the country was established. Passing to the industrial activities we may note—first, that through sundry steps, from 1873 onward, there has been a progressive transfer of railways into the hands of the state; so that, partly by original construction (mainly of lines for military purposes), and partly by purchase, three fourths of all Prussian railways have been made government property; and the same percentage holds in the other German states: the aim being eventually to make them all imperial. Trade interferences have been extended in various ways—by protectionist tariffs, by revival of the usury laws, by restrictions on Sunday labor. Through its postal service the state has assumed industrial functions—presents acceptances, receives money on

bills of exchange that are due, as also on ordinary bills, which it gets receipted; and, until stopped by shopkeepers' protests, undertook to procure books from publishers. Lastly there come the measures for extending, directly and indirectly, the control over popular life. On the one hand, there are the laws under which, up to the middle of last year, two hundred and twenty-four socialist societies have been closed, one hundred and eighty periodicals suppressed, three hundred and seventeen books, etc., forbidden, and under which sundry places have been reduced to a partial state of siege. On the other hand, may be named Prince Bismarck's scheme for reëstablishing guilds (bodies which by their regulations coerce their members), and his scheme of state insurance, by the help of which the artisan would in a considerable degree have his hands tied. Though these measures have not been carried in the forms proposed, yet the proposal of them sufficiently shows the general tendency. In all which changes we see progress toward a more integrated structure, toward increase of the militant part as compared with the industrial part, toward the replacing of civil organization by military organization, toward the strengthening of restraints over the individual and regulation of his life in greater detail.

The remaining example to be named is that furnished by our own society since the revival of military activity—a revival which has of late been so marked that our illustrated papers are, week after week, occupied with little else than scenes of warfare. Already in the first volume of "The Principles of Sociology," I have pointed out many ways in which the system of compulsory coöperation characterizing the militant type has been trenching on the system of voluntary cooperation characterizing the industrial type; and, since those passages appeared (July, 1876), other changes in the same direction have taken place. Within the military organization itself, we may note the increasing assimilation of the volunteer forces to the regular army, now going to the extent of a movement for making them available abroad, so that, instead of defensive action for which they were created, they can be used for offensive action; and we may also note that the tendency shown in the army during a past generation to sink the military character whenever possible, by putting on civilian dresses, is now checked by an order to officers in garrison towns to wear their uniforms when off duty, as they do in more militant countries. Whether, since the date named, usurpations of civil functions by military men (which had in 1873–'74 gone to the extent that there were ninety-seven colonels, majors, captains, and lieutenants employed from time to time as inspectors of science and art classes) have gone further I can not say; but there has been a manifest extension of the military spirit and discipline among the police, with the effect that, wearing helmet-shaped hats, beginning to carry revolvers, and looking on themselves as half soldiers, they have come to speak of the people as "civil-

ians," and in some cases exercise over "civilians" an inspection of a military kind; as instance the chief of the Birmingham police, Major Bond, whose subalterns track home men who are unsteady from drink but quiet, and prosecute them next morning; or as instance the regulation by policemen's commands of the conflicting streams of vehicles in the London streets. To an increasing extent the executive has been overriding the other governmental agencies; as in the Cyprus business, and as in the doings of the Indian Viceroy under secret instructions from home. In various minor ways are shown endeavors to free officialism from popular checks; as in the desire expressed in the House of Lords that the hanging of convicts in prisons, intrusted entirely to the authorities, should have no other witnesses; and as in the advice given by the late Home Secretary (on May 11, 1878) to the Derby town council, that it should not interfere with the chief constable (a military man) in his government of the force under him—a step toward centralizing local police control in the home office. Simultaneously we see various actual or prospective extensions of public agency, replacing or restraining private agency. There is the "endowment of research," which, already partially carried out by a government fund, many wish to carry further; there is the proposed act for establishing a registration of authorized teachers; there is the bill which provides central inspection for local public libraries; there is the scheme for compulsory insurance—a scheme showing us in an instructive manner the way in which the regulating policy extends itself: compulsory charity having generated improvidence, there comes compulsory insurance as a remedy for the improvidence. Other proclivities toward institutions belonging to the militant type are seen in the increasing demand for some form of protection, and in the lamentations uttered by the "society papers" that dueling has gone out. Nay, even through the party which by position and function is antagonistic to militancy, we see that militant discipline is spreading; for the caucus-system, established for the better organization of liberalism, is one which necessarily, in a greater or less degree, centralizes authority and controls individual action.

Besides seeing, then, that the traits to be inferred *a priori* as characterizing the militant type constantly exist in societies which are permanently militant in high degrees, we also see that in other societies increase of militant activity is followed by development of such traits.

In some places I have stated, and in other places implied, that a necessary relation exists between the structure of a society and the natures of its citizens. Here it will be well to observe in detail the characters proper to, and habitually exemplified by, the members of a typically militant society.

Other things equal, a society will be successful in war in propor-

tion as its members are endowed with bodily vigor and courage. And, on the average, among conflicting societies there will be a survival and spread of those in which the physical and mental powers called for in battle are not only most marked but also most honored. Egyptian and Assyrian sculptures and inscriptions show us that prowess was the thing above all others thought most worthy of record. Of the words good, just, etc., as used by the ancient Greeks, Grote remarks that they "signify the man of birth, wealth, influence, and daring, whose arm is strong to destroy or to protect, whatever may be the turn of his moral sentiments; while the opposite epithet, bad, designates the poor, lowly, and weak, from whose dispositions, be they ever so virtuous, society has little to hope or to fear." In the identification of virtue with bravery among the Romans, we have a like implication. During early turbulent times throughout Europe, the knightly character, which was the honorable character, primarily included fearlessness: lacking this, good qualities were of no account; but, with this, sins of many kinds were condoned.

If, among antagonist groups of primitive men, some tolerated more than others the killing of their members—if, while some always retaliated, others did not—those which did not retaliate, continually aggressed on with impunity, would either gradually disappear or have to take refuge in undesirable habitats. Hence there is a survival of the unforgiving. Further, the *lex talionis*, primarily arising between antagonist groups, becomes the law within the group; and chronic feuds between component families and clans everywhere proceed upon the general principle of life for life. Under the militant *régime* revenge becomes a virtue, and failure to revenge a disgrace. Among the Feejeeans, who foster anger in their children, it is not infrequent for a man to commit suicide rather than live under an insult—rather than submit to an unavenged injury; and in other cases the dying Feejeean bequeaths the duty of inflicting vengeance to his children. This sentiment and resulting practices we trace among peoples otherwise wholly alien, who are, or have been, actively militant. In the remote East may be instanced the Japanese. They are taught that "with the slayer of his father a man may not live under the same heaven; against the slayer of his brother a man must never have to go home to fetch a weapon; with the slayer of his friend a man may not live in the same state." And in the West may be instanced France during feudal days, when the relations of one killed or injured were required by custom to retaliate on any relations of the offender—even those living at a distance, and knowing nothing of the matter. Down even to the time of the Abbé Brantôme the spirit was such that that ecclesiastic, bequeathing to his nephews the duty of avenging any unredressed wrongs done to him in his old age, says of himself: "I may boast, and I thank God for it, that I never received an injury without being revenged on the author of it." That, where militancy is active,

revenge, private as well as public, becomes a duty, is well shown at the present time among the Montenegrins—a people who have been at war with the Turks for centuries. "Dans le Montenegro," says Boué, "on dira d'un homme d'une natrie [clan] ayant tué un individu d'une autre: Cette natrie nous doit une tête, et il faut que cette dette soit acquitté, car qui ne se venge pas ne ce sancitie pas."

Where activity in destroying enemies is chronic, destruction will become a source of pleasure; where success in subduing fellow-men is above all things honored, there will arise delight in the forcible exercise of mastery; and, with pride in spoiling the vanquished, will go disregard for the rights of property at large. As it is incredible that men should be courageous in face of foes and cowardly in face of friends, so it is incredible that the other feelings fostered by perpetual conflicts abroad should not come into play at home. We have just seen that, with the pursuit of vengeance outside the society, there goes the pursuit of vengeance inside the society; and whatever other habits of thought and action constant war necessitates must show their effects in the social life at large. Facts from various places and times prove that in militant societies the claims of life, liberty, and property are little regarded. The Dahomans, warlike to the extent that both sexes are warriors, and by whom slave-hunting invasions are, or were, annually undertaken "to furnish funds for the royal exchequer," show their blood-thirstiness by their annual "customs," at which multitudinous victims are publicly slaughtered for the popular gratification. The Feejeeans, again, highly militant in their activities and type of organization, who display their recklessness of life not only by killing their own people for cannibal feasts, but by destroying immense numbers of their infants and by sacrificing victims on trivial occasions, such as launching a new canoe, so much applaud ferocity that to commit a murder is a glory. Early records of Asiatics and Europeans show us the like relation. What accounts there are of the primitive Mongols, who, when united, massacred Western peoples wholesale, show us a chronic reign of violence, both within and without their tribes; while domestic assassinations, which from the beginning have characterized the militant Turks, continue to characterize them down to our own day! In proof that it was so with the Greek and Latin races, it suffices to instance the slaughter of the two thousand Helots by the Spartans, whose brutality was habitual, and the murder of large numbers of suspected citizens by jealous Roman emperors, who also, like their subjects, manifested their love of bloodshed in their arenas. That where life is little regarded there can be but little regard for liberty, follows necessarily: those who do not hesitate to end another's activities by killing him will still less hesitate to restrain his activities by holding him in bondage. Militant savages, whose captives, when not eaten, are enslaved, habitually show us this absence of regard for fellow-men's freedom, which characterizes the members

of militant societies in general. How little, under the militant *régime*, more or less markedly displayed in all early historic societies, there was any sentiment against depriving men of their liberties, is sufficiently shown by the fact that even in the teachings of primitive Christianity there was no express condemnation of slavery. Naturally the like holds with the right of property. Where mastery established by force is honorable, claims to possession by the weaker are likely to be little respected by the stronger. In Feejee it is considered chief-like to seize a subject's goods; and theft is virtuous if undiscovered. In Dahomey the king "squeezes" any one as soon as he acquires property. Among the Spartans "the ingenious and successful pilferer gained applause with his booty." In mediæval Europe with perpetual robberies of one society by another there went perpetual robberies within each society. Under the Merovingians "the murders and crimes it ["The Ecclesiastical History of the Franks"] relates have almost all for their object the possession of the treasure of the murdered persons"; and under Charlemagne plunder by officials was chronic: the moment his back was turned "the provosts of the king appropriated the funds intended to furnish food and clothing for the artisans."

Where warfare is habitual, and the required qualities most needful and therefore most honored, those whose lives do not display them are treated with contempt, and their occupations regarded as dishonorable. In early stages labor is the business of women and of slaves—conquered men and the descendants of conquered men; and trade of every kind, carried on by subject classes, long continues to be identified with lowness of origin and nature. In Dahomey, "agriculture is despised because slaves are employed in it." "The Japanese nobles and placemen, even of secondary rank, entertain a sovereign contempt for traffic." Of the ancient Egyptians Wilkinson says, "Their prejudices against mechanical employments, as far as regarded the soldier, were equally strong as in the rigid Sparta." "For trade and commerce the (ancient) Persians were wont to express extreme contempt," writes Rawlinson. The progress of class differentiation which accompanied the conquering wars of the Romans, was furthered by establishment of the rule that it was disgraceful to take money for work, and also by the law forbidding senators and senators' sons from engaging in speculation. And how great has been the scorn expressed by the militant classes for the trading classes throughout Europe down to quite recent times, needs no showing.

That there may be willingness to risk life for the benefit of the society, there must be much of the feeling called patriotism. Though the belief that it is glorious to die for one's country can not be regarded as essential, since mercenaries fight without it, yet it is obvious that such a belief must conduce greatly to success in war; and that entire absence of it must be so unfavorable to offensive and de-

fensive action that failure and subjugation, will, other things equal, be likely to result. Hence the sentiment of patriotism will be established by the survival of societies the members of which are most characterized by it.

With this there needs to be united the instinct of obedience. The possibility of that united action by which, other things equal, war is made successful, depends on the readiness of individuals to subordinate their wills to the will of a commander or ruler. Loyalty is essential. In early stages the manifestation of it is but temporary, as among the Araucanians, who, ordinarily showing themselves "repugnant to all subordination, are then (when war is impending) prompt to obey, and submissive to the will of their military sovereign" appointed for the occasion. And with development of the militant type this sentiment becomes permanent. Thus, Erskine tells us that the Feejeeans are intensely loyal: men buried alive in the foundations of a king's house considered themseves honored by being so sacrificed; and the people of a slave district "said it was their duty to become food and sacrifice for the chiefs." So in Dahomey there is felt for the king "a mixture of love and fear, little short of adoration." In ancient Egypt, again, where "blind obedience was the oil which caused the harmonious working of the machinery" of social life, the monuments on every side show with wearisome iteration the daily acts of subordination—of slaves and others to the dead man, of captives to the king, of the king to the gods. Though, for reasons already pointed out, chronic war did not generate in Sparta a supreme political head, to whom there could be shown implicit obedience, yet the obedience shown to the political agency which grew up was profound: individual wills were in all things subordinate to the public will expressed by the established authorities. In primitive Rome, too, in the absence of a divinely-descended king to whom submission could be shown, there was submission to an appointed king, qualified only by expressions of opinion on special occasions; and the principle of absolute obedience, slightly mitigated in the relations of the community as a whole to its ruling agency, was unmitigated within its component groups. And that throughout European history, alike on small and on large scales, we see the sentiment of loyalty dominant where the militant type of structure is pronounced, is a truth that will be admitted without detailed proof.

From these conspicuous traits of nature let us turn to certain consequent traits which are less conspicuous, and which have results of less manifest kinds. Along with loyalty naturally goes faith—the two being, indeed, scarcely separable. Readiness to obey the commander in war implies belief in his military abilities; and readiness to obey him during peace implies belief that his abilities extend to civil affairs also. Imposing on men's imaginations, each new conquest augments his authority. There come more frequent and more decided

evidences of his regulative action over men's lives; and these generate the idea that his power is boundless. Unlimited faith in governmental agency is fostered. Generations brought up under a system which controls all affairs, private and public, tacitly assume that affairs can only thus be controlled. Those who have experience of no other *régime* become unable to imagine any other *régime*. In such societies as that of ancient Peru, for example, where, as we have seen, regimental rule was universal, there were no materials for framing the thought of an industrial life spontaneously carried on and spontaneously regulated.

By implication, there result repression of individual initiative and a consequent lack of private enterprise. In proportion as an army becomes organized it is reduced to a state in which the independent action of its members is forbidden. And, in proportion as regimentation pervades the society at large, each member of it, directed or restrained at every turn, has little or no power of conducting his business otherwise than by established routine. Slaves can do only what they are told by their masters; their masters can not do anything that is unusual without official permission; and no permission is to be obtained from the local authority until superior authorities through their ascending grades have been consulted. Hence the mental state generated is that of passive acceptance and expectancy. Where the militant type is fully developed, everything must be done by public agencies; not only for the reason that these occupy all spheres, but for the further reason that, did they not occupy them, there would arise no other agencies—the prompting ideas and sentiments having been obliterated.

There must be added a concomitant influence on the intellectual nature which coöperates with the moral influences just named. Personal causation is alone recognized, and the conception of impersonal causation is prevented from developing. The primitive man has no idea of cause in the modern sense. The only agents included in his theory of things are living persons and the ghosts of dead persons. All unusual occurrences, together with those usual ones liable to variation, he ascribes to supernatural beings. And this system of interpretration survives through early stages of civilization; as we see, for example, among the Homeric Greeks, by whom wounds, deaths, and escapes in battle, were ascribed to the enmity or the aid of the gods, and by whom good and bad acts were held to be divinely prompted. Continuance and development of militant forms and activities maintain this way of thinking. In the first place it indirectly hinders the discovery of causal relations. The sciences grow out of the arts—begin as generalizations of truths which practice of the arts makes manifest. In proportion as processes of production multiply in their kinds and increase in their complexities, more numerous uniformities come to be recognized; and the ideas of necessary relation and physi-

cal cause arise and develop. Consequently, by discouraging industrial progress, militancy checks the replacing of ideas of personal agency by ideas of impersonal agency. In the second place, it does the like by direct repression of intellectual culture. Naturally a life occupied in acquiring knowledge, like a life occupied in industry, is regarded with contempt by a people devoted to war. The Spartans clearly exemplified this relation in ancient times; and it was again exemplified during feudal ages in Europe, when learning was scorned as proper only for clerks and the children of mean people. And obviously, in proportion as warlike activities are antagonistic to the advance of science, they further retard that emancipation from primitive ideas which ends in recognition of natural uniformities. In the third place, and chiefly, the effect in question is produced by the conspicuous and perpetual experience of personal agency which the militant *régime* yields. In the army, from the commander-in-chief down to the private undergoing drill, every movement is directed by a superior; and, throughout the society, in proportion as its regimentation is elaborate, things are hourly seen to go thus or thus, according to the regulating wills of the ruler and his subordinates. In the interpretation of social affairs, personal causation is consequently alone recognized. History comes to be made up of the doings of remarkable men; and it is tacitly assumed that societies have been formed by them. Wholly foreign to the habit of mind as is the thought of impersonal causation, the course of social evolution is unperceived. The natural genesis of social structures and functions is an utterly alien conception, and appears absurd when alleged. The notion of a self-regulating social process is unintelligible. So that militancy molds the citizen into a form not only morally adapted, but intellectually adapted—a form which can not think away from the entailed system.

In three ways, then, we are shown the character of the militant type of political organization. Observe the congruities which comparison of results discloses.

Certain conditions, manifest *a priori*, have to be fulfilled by a society fitted for preserving itself in presence of antagonist societies. To be in the highest degree efficient, the corporate action needed for preserving the corporate life must be joined in by every one. Other things equal, the fighting power will be greatest where those who can not fight labor exclusively to support and help those who can: an evident implication being that the working part shall be no larger than is required for these ends. The efforts of all being utilized directly or indirectly for war, will be most effectual when they are most combined; and, besides union among the combatants, there must be such union of the non-combatants with them as renders the aid of these fully and promptly available. To satisfy these requirements, the life, the actions, and the possessions of each individual must be

held at the service of the society. This universal service, this combination, and this merging of individual claims, presuppose a despotic controlling agency. That the will of the soldier-chief may be operative when the aggregate is large, there must be sub-centers and sub-sub-centers in descending grades, through whom orders may be conveyed and enforced, both throughout the combatant part and the non-combatant part. As the commander tells the soldier both what he shall not do and what he shall do, so, throughout the militant community at large, the rule is both negatively regulative and positively regulative: it not only restrains, but it directs: the citizen as well as the soldier lives under a system of compulsory coöperation. Development of the militant type involves increasing rigidity, since the cohesion, the combination, the subordination, and the regulation, to which the units of a society are subjected by it, inevitably decrease their ability to change their social positions, their occupations, their localities.

On inspecting sundry societies, past and present, large and small, which are, or have been, characterized in high degrees by militancy, we are shown, *a posteriori*, that amid the differences due to race, to circumstances, and to degrees of development, there are fundamental similarities of the kinds above inferred *a priori*. Modern Dahomey and Russia, as well as ancient Peru, Egypt, and Sparta, exemplify that owning of the individual by the state in life, liberty, and goods, which is proper to a social system adapted for war. And, that, with changes further fitting a society for warlike activities, there spread throughout it an officialism, a dictation, and a superintendence, akin to those under which the soldiery lives, we are shown by imperial Rome, by imperial Germany, and by England since its late aggressive activities.

Lastly comes the evidence furnished by the adapted characters of the men who compose militant societies. Making success in war the highest glory, they are led to identify goodness with bravery and strength. Revenge becomes a sacred duty with them; and, acting at home on the law of retaliation which they act on abroad, they similarly at home as abroad are ready to sacrifice others to self: their sympathies, continually deadened in war, can not be active during peace. They must have a patriotism which regards the triumph of their society as the supreme end of the action; they must possess the loyalty whence flows obedience to authority; and that they may be obedient they must have abundant faith. With faith in authority and consequent readiness to be directed, naturally goes relatively little power of initiation. The habit of seeing everything officially controlled fosters the belief that official control is everywhere needful; and a course of life which makes personal causation familiar and negatives experience of impersonal causation produces an inability to conceive of any social processes as carried on under self-regulating arrange-

ments. And these traits of individual nature, needful concomitants as we see of the militant type, are those which we observe in the members of actual militant societies.

THE CULTIVATION OF MEDICAL SCIENCE.

OPENING ADDRESS BEFORE THE INTERNATIONAL MEDICAL CONGRESS.

By the President, Sir JAMES PAGET.

AS I look around this hall my admiration is moved not only by the number and total power of the minds which are here, but by their diversity, a diversity in which I believe they fairly represent the whole of those who are engaged in the cultivation of our science. For here are minds representing the distinctive characters of all the most gifted and most educated nations: characters still distinctly national, in spite of the constantly increasing intercourse of the nations. And from many of these nations we have both elder and younger men; thoughtful men and practical; men of fact and men of imagination; some confident, some skeptic; various, also, in education, in purpose and mode of study, in disposition, and in power. And scarcely less various are the places and all the circumstances in which those who are here have collected and have been using their knowledge. For I think that our calling is preëminent in its range of opportunities for scientific study. It is not only that the pure science of human life may match with the largest of the natural sciences in the complexity of its subject-matter; not only that the living human body is, in both its material and its indwelling forces, the most complex thing yet known, but that in our practical duties this most complex thing is presented to us in an almost infinite multiformity. For in practice we are occupied, not with a type and pattern of the human nature, but with all its varieties in all classes of men, of every age and every occupation, and all climates and all social states; we have to study men singly and in multitudes, in poverty and in wealth, in wise and unwise living, in health and all the varieties of disease; and we have to learn, or at least try to learn, the results of all these conditions of life, while in successive generations and in the mingling of families they are heaped together, confused, and always changing. In every one of all these conditions, man, in mind and body, must be studied by us; and every one of them offers some different problems for inquiry and solution. Wherever our duty or our scientific curiosity, or, in happy combination, both, may lead us, there are the materials and there the opportunities for separate original research.

Now, from these various opportunities of study, men are here in

Congress. Surely, whatever a multitude and diversity of minds can in a few days do for the promotion of knowledge, may be done here.

But it is not proposed to leave the work of the Congress to what would seem like chances and disorder, good as the result might be; nor yet to the personal influences by which we may all be made fitter for work, though these may be very potent. In the stir and controversy of meetings such as we shall have, there can not fail to be useful emulation; by the examples that will appear of success in research, many will be moved to more enthusiasm, many to more keen study of the truth; our range of work will be made wider, and we shall gain that greater interest in each other's views and that clearer apprehension of them which are always attained by personal acquaintance and by memories of association in pleasure as well as in work. But as it will not be left to chance, so neither will sentiment have to fulfill the chief duties of the Congress.

Following the good example of our predecessors, certain subjects have been selected which will be chiefly though not exclusively discussed, and the discussions are to be in the sections into which we shall soon divide.

Of these subjects it would not be for me to speak even if I were competent to do so; unless I may say that they are so numerous and complete that—together with the opening addresses of the presidents of sections—they leave me nothing but such generalities as may seem commonplace. They have been selected, after the custom of former meetings, from the most stirring and practical questions of the day; they are those which must occupy men's minds, and on which there is at this time most reason to expect progress, or even a just decision, from very wide discussion. They will be discussed by those most learned in them, and in many instances by those who have spent months or years in studying them, and who now offer their work for criticism and judgment.

I will only observe that the subjects selected in every section involve questions in the solution of which all the varieties of mind and knowledge of which I have spoken may find their use. For there are questions, not only on many subjects, but in all stages of progress toward settlement. In some the chief need seems to be the collection of facts well observed by many persons. I say by many, not only because many facts are wanted, but because in all difficult research it is well that each apparent fact should be observed by many; for things are not what they appear to each one mind. In that which each man believes that he observes, there is something of himself; and for certainty, even on matters of fact, we often need the agreement of many minds, that the personal element of each may be counteracted. And much more is this necessary in the consideration of the many questions which are to be decided by discussing the several values of admitted facts and of probabilities, and of the conclusions drawn from them.

For, on questions such as these, minds of all kinds may be well employed. Here there will be occasion even for those which are not unconditionally praiseworthy, such as those that habitually doubt, and those to whom the invention of arguments is more pleasing than the mere search for truth. Nay, we may be able to observe the utility even of error. We may not, indeed, wish for a prevalence of errors; they are not more desirable than are the crime and misery which evoke charity. And yet in a congress we may palliate them, for we may see how, as we may often read in history, errors, like doubts and contrary pleadings, serve to bring out the truth, to make it express itself in clearest terms and show its whole strength and value. Adversity is an excellent school for truth as well as for virtue.

But that which I would chiefly note, in relation to the great variety of minds which are here, is that it is characteristic of that mental pliancy and readiness for variation which is essential to all scientific progress, and which a great international congress may illustrate and promote. In all the subjects for discussion we look for the attainment of some novelty and change in knowledge or belief; and after every such change there must ensue a change in some of the conditions of thinking and of working. Now, for all these changes minds need to be pliant and quick to adjust themselves. For all progressive science there must be minds that are young, whatever may be their age.

Just as the discovery of auscultation brought to us the necessity for a refined cultivation of the sense of hearing, which was before of only the same use in medicine as in the common business of life; or, as the employment of the numerical method in estimating the value of facts required that minds should be able to record and think in ways previously unused; or, as the acceptance of the doctrine of evolution has changed the course of thinking in whole departments of science—so is it, in less measure, in every less advance of knowledge. All such advances change the circumstances of the mental life, and minds that can not or will not adjust themselves become less useful, or must at least modify their manner of utility. They may continue to be the best defenders of what is true; they may strengthen and expand the truth, and may apply it in practice with all the advantages of experience; they may thus secure the possessions of science and use them well; but they will not increase them.

It is with minds as with living bodies. One of their chief powers is in their self-adjustment to the varying conditions in which they have to live. Generally those species are the strongest and most abiding that can thrive in the widest range of climate and of food. And of all the races of men they are the mightiest and most noble who are, or by self-adjustment can become, most fit for all the new conditions of existence in which by various changes they may be placed. These are they who prosper in great changes of their social state; who, in successive generations, grow stronger by the production of a population

so various that some are fitted to each of all the conditions of material and mode of life which they can discover or invent. These are most prosperous in the highest civilization; these whom nature adapts to the products of their own arts.

Or, among other groups, the mightiest are those who are strong alike on land and sea; who can explore and colonize, and in every climate can replenish the earth and subdue it; and this not by tenacity or mere robustness, but rather by pliancy and the production of varieties fit to abide and increase in all the various conditions of the world around.

Now, it is by no distant analogy that we trace the likeness between these in their successful contests with the material conditions of life and those who are to succeed in the intellectual strife with the difficulties of science and of art. There must be minds which in variety may match with all the varieties of the subject-matters and minds which, at once or in swift succession, can be adjusted to all the increasing and changing modes of thought and work.

Such are the minds we need; or, rather, such are the minds we have; and these in great meetings prove and augment their worth. Happily the natural increase in the variety of minds in all cultivated races is—whether as cause or as consequence—nearly proportionate to the increasing variety of knowledge. And it has become proverbial, and is nearly true in science and art, as it is in commerce and in national life, that, whatever work is to be done, men are found or soon produced who are exactly fit to do it.

But it need not be denied that, in the possession of this first and chiefest power for the increase of knowledge, there is a source of weakness. In works done by dissimilar and independent minds, dispersed in different fields of study, or only gathered into self-assorted groups, there are apt to be discord and great waste of power. There is, therefore, need that the workers should from time to time be brought to some consent and unity of purpose; that they should have opportunity for conference and mutual criticism, for mutual help and the tests of free discussion. This it is which, on the largest scale and most effectually, our Congress may achieve; not indeed by striving after a useless and happily impossible uniformity of mind or method, but by diminishing the lesser evil of waste and discord which is attached to the far greater good of diversity and independence. Now, as in numbers and variety the Congress may represent the whole multitude of workers everywhere dispersed, so in its gathering and concord it may represent a common consent that, though we may be far apart and different, yet our work is and shall be essentially one; in all its parts mutually dependent, mutually helpful, in no part complete or self-sufficient. We may thus declare that as we who are many are met to be members of one body, so our work for science shall be one, though manifold; that as we, who are of many nations, will for a time forget

our nationalities, and will even repress our patriotism, unless for the promotion of a friendly rivalry, so will we in our work, whether here and now or everywhere and always, have one end and one design—the promotion of the whole science and whole art of healing.

It may seem to be a denial of this declaration of unity that, after this general meeting, we shall separate into sections more numerous than in any former Congress. Let me speak of these sections to defend them; for some maintain that, even in such a division of studies as these may encourage, there is a mischievous dispersion of forces. The science of medicine, which used to be praised as one and indivisible, is broken up, they say, among specialists, who work in conflict rather than in concert, and with mutual distrust more than mutual help.

But let it be observed that the sections which we have instituted are only some of those which are already recognized in many countries, in separate societies, each of which has its own place and rules of self-government and its own literature. And the division has taken place naturally in the course of events which could not be hindered. For the partial separation of medicine, first from the other natural sciences, and now into sections of its own, has been due to the increase of knowledge being far greater than the increase of individual mental power.

I do not doubt that the average mental power constantly increases in the successive generations of all well-trained peoples; but it does not increase so fast as knowledge does, and thus in every science, as well as in our own, a small portion of the whole sum of knowledge has become as much as even a large mind can hold and duly cultivate. Many of us must, for practical life, have a fair acquaintance with many parts of our science, but none can hold it all; and for complete knowledge, or for research, or for safely thinking out beyond what is known, no one can hope for success unless by limiting himself within the few divisions of the science for which, by nature or by education, he is best fitted. Thus, our division into sections is only an instance of that division of labor which, in every prosperous nation, we see in every field of active life, and which is always justified by more work better done.

Moreover, it can not be said that in any of our sections there is not enough for a full, strong mind to do. If any one will doubt this, let him try his own strength in the discussions of several of them.

In truth, the fault of specialism is not in narrowness, but in the shallowness and the belief in self-sufficiency with which it is apt to be associated. If the field of any specialty in science be narrow, it can be dug deeply. In science, as in mining, a very narrow shaft, if only it be carried deep enough, may reach the richest stores of wealth and find use for all the appliances of scientific art. Not in medicine alone, but in every department of knowledge, some of the grandest results of research and of learning, broad and deep, are to be found

in monographs on subjects that, to the common mind, seemed small and trivial.

And study in a Congress such as this may be a useful remedy for self-sufficiency. Here every group may find a rare occasion, not only for an opportune assertion of the supreme excellence of its own range and mode of study, but for the observation of the work of every other. Each section may show that its own facts must be deemed sure, and that by them every suggestion from without must be tested; but each may learn to doubt every inference of its own which is not consistent with the facts or reasonable beliefs of others; each may observe how much there is in the knowledge of others which should be mingled with its own; and the sum of all may be the wholesome conviction of all, that we can not justly estimate the value of a doctrine in one part of our science till it has been tried in many or in all.

We were taught this in our schools; and many of us have taught that all the parts of medical science are necessary to the education of the complete practitioner. In the independence of later life some of us seem too ready to believe that the parts we severally choose may be self-sufficient, and that what others are learning can not much concern us. A fair study of the whole work of the Congress may convince us of the fallacy of this belief. We may see that the test of truth in every part must be in the patient and impartial trial of its adjustment with what is true in every other. All perfect organizations bear this test; all parts of the whole body of scientific truth should be tried by it.

Moreover, I would not, from a scientific point of view, admit any estimate of the comparative importance of the several divisions of our science, however widely they may differ in their present utilities. And this I would think right, not only because my office as president binds me to a strict impartiality and to the claim of freedom of research for all, but because we are very imperfect judges of the whole value of any knowledge, or even of single facts. For every fact in science, wherever gathered, has not only a present value, which we may be able to estimate, but a living and germinal power of which none can guess the issue.

It would be difficult to think of anything that seemed less likely to acquire practical utility than those researches of the few naturalists who, from Leeuwenhoek to Ehrenberg, studied the most minute of living things, the *Vibrionidæ*. Men boasting themselves as practical might ask, "What good can come of it?" Time and scientific industry have answered: "This good—those researches have given a more true form to one of the most important practical doctrines of organic chemistry; they have introduced a great beneficial change in the most practical part of surgery; they are leading to one as great in the practice of medicine; they concern the highest interests of agriculture, and their power is not yet exhausted."

And as practical men were, in this instance, incompetent judges of the value of scientific facts, so were men of science at fault when they missed the discovery of anæsthetics. Year after year the influences of laughing-gas and of ether were shown: the one fell to the level of the wonders displayed by itinerant lecturers, students made fun with the other; they were the merest practical men, men looking for nothing but what might be straightway useful, who made the great discovery which has borne fruit not only in the mitigation of suffering, but in a wide range of physiological science.

The history of science has many similar facts, and they may teach that any man will be both wise and dutiful if he will patiently and thoughtfully do the best he can in the field of work in which, whether by choice or chance, his lot is cast. There let him, at least, search for truth, reflect on it, and record it accurately; let him imitate that accuracy and completeness of which I think we may boast that we have, in the descriptions of the human body, the highest instance yet attained in any branch of knowledge. Truth so recorded can not remain barren.

In thus speaking of the value of careful observation and records of facts, I seem to be in agreement with the officers of all the sections; for, without any intended consent, they have all proposed such subjects for discussion as can be decided only by well-directed facts and fair direct inductions from them. There are no questions on theories or mere doctrines. This, I am sure, may be ascribed, not to any disregard of the value of good reasoning or of reasonable hypotheses, but partly to the just belief that such things are ill-suited for discussion in large meetings, and partly to the fact that we have no great opponent schools, no great parties named after leaders or leading doctrines about which we are in the habit of disputing. In every section the discussions are to be on definite questions, which, even if they be associated with theory or general doctrines, may yet be soon brought to the test of fact; there is to be no use of doctrinal touchstones.

I am speaking of no science but our own. I do not doubt that in others there is advantage in dogma, or in the guidance of a central organizing power, or in divisions and conflicting parties. But in the medical sciences I believe that the existence of parties founded on dominant theories has always been injurious; a sign of satisfaction with plausible errors, or with knowledge which was even for the time imperfect. Such parties used to exist, and the personal histories of their leaders are some of the most attractive parts of the history of medicine: but, although in some instances an enthusiasm for the master-mind may have stirred a few men to unusual industry, yet very soon the disciples seem to have been fascinated by the distinctive doctrine, content to bear its name, and to cease from active scientific work. The dominance of doctrine has promoted the habit of inference, and repressed that of careful observation and induction. It has encouraged

that fallacy to which we are all too prone, that we have at length reached an elevated sure position on which we may rest, and only think and guide. In this way specialism in doctrine or in method of study has hindered the progress of science more than the specialism which has attached itself to the study of one organ or of one method of practice. This kind of specialism may enslave inferior minds: the specialism of doctrine can enchant into mere dreaming those that should be strong and alert in the work of free research.

I speak the more earnestly of this because it may be said, if our Congress be representative, as it surely is, may we not legislate? May we not declare some general doctrines which may be used as tests and as guides for future study? We had better not.

The best work of our International Congress is in the clearing and strengthening of the knowledge of realities; in bringing, year after year, all its force of numbers and varieties of minds to press forward the demonstration and diffusion of truth as nearly to completion as may from year to year be possible. Thus, chiefly, our Congress may maintain and invigorate the life of our science. And the progress of science must be as that of life. It sounds well to speak of the temple of science, and of building and crowning the edifice. But the body of science is not as any dead thing of human work, however beautiful; it is as something living, capable of development and a better growth in every part. For, as in all life the attainment of the highest condition is only possible through the timely passing-by of the less good, that it may be replaced by the better, so is it in science. As time passes, that which seemed true and was very good becomes relatively imperfect truth, and the truth more nearly perfect takes its place.

We may read the history of the progress of truth in science as a paleontology. Many things which, as we look far back, appear, like errors, monstrous and uncouth creatures, were, in their time, good and useful, as good as possible. They were the lower and less perfect forms of truth which, amid the floods and stifling atmospheres of error, still survived; and just as each successive condition of the organic world was necessary to the evolution of the next following higher state, so from these were slowly evolved the better forms of truth which we now hold.

This thought of the likeness between the progress of scientific truth and the history of organic life may give us all the better courage in a work which we can not hope to complete, and in which we see continual and sometimes disheartening change. It is, at least, full of comfort to those of us who are growing old. We that can read in memory the history of half a century might look back with shame and deep regret at the imperfections of our early knowledge if we might not be sure that we held, and sometimes helped onward, the best things that were, in their time, possible, and that they were necessary steps to the better present, even as the present is to the still better future.

Yes—to the far better future; for there is no course of Nature more certain than is the upward progress of science. We may seem to move in circles, but they are the circles of a constantly ascending spiral; we may seem to sway from side to side, but it is only as on a steep ascent which must be climbed in zigzag.

What may be the knowledge of the future none can guess. If we could conceive a limit to the total sum of mental power which will be possessed by future multitudes of well-instructed men, yet could we not conceive a limit to the discovery of the properties of materials which they will bend to their service. We may find the limit of the power of our unaided limbs and senses; but we can not guess at a limit to the means by which they may be assisted, or to the invention of instruments which will become only a little more separate from our mental selves than are the outer sense-organs with which we are constructed.

In the certainty of this progress the great question for us is, what shall we contribute to it? It will not be easy to match the recent past. The advance of medical knowledge within one's memory is amazing, whether reckoned in the wonders of the science not yet applied, or in practical results in the general lengthening of life, or, which is still better, in the prevention and decrease of pain and misery, and in the increase of working power. I can not count or recount all that in this time has been done; and I suppose there are very few, if any, who can justly tell whether the progress of medicine has been equal to that of any other great branch of knowledge during the same time. I believe it has been; I know that the same rate of progress can not be maintained without the constant and wise work of thousands of good intellects; and the mere maintenance of the same rate is not enough, for the rate of the progress of science should constantly increase. That in the last fifty years was at least twice as great as that in the previous fifty. What will it be in the next, or, for a more useful question, what shall we contribute to it?

I have no right to prescribe for more than this week. In this let us do heartily the proper work of the Congress, teaching, learning, discussing, looking for new lines for research, planning for mutual help, forming new friendships. It will be hard work if we will do it well; but we have not met for mere amusement or for recreation, though for that I hope you will find fair provision, and enjoy it the better for the work preceding it.

And when we part let us bear away with us, not only much more knowledge than we came with, but some of the lessons for our conduct in the future which we may learn in reflecting the work of our Congress.

In the number and intensity of the questions brought before us, we may see something of our responsibility. If we could gather into thought the amounts of misery or happiness, of helplessness or of

power for work, which may depend on the answers to all the questions that will come before us, this might be a measure of our responsibility. But we can not count it; let us imagine it; we can not even in imagination exaggerate it. Let us bear it always in our mind, and remind ourselves that our responsibility will constantly increase. For, as men become in the best sense better educated, and the influence of scientific knowledge on their moral and social state increases, so among all sciences there is none of which the influence, and therefore the responsibility, will increase more than ours, because none more intimately concerns man's happiness and working power.

But, more clearly in the recollections of the Congress, we may be reminded that in our science there may be, or, rather, there really is, a complete community of interest among men of all nations. On all the questions before us we can differ, discuss, dispute, and stand in earnest rivalry; but all consistently with friendship, all with readiness to wait patiently till more knowledge shall decide which is in the right. Let us resolutely hold to this when we are apart: let our internationality be a clear abiding sentiment, to be, as now, declared and celebrated at appointed times, but never to be forgotten; we may, perhaps, help to gain a new honor for science, if we thus suggest that in many more things, if they were as deeply and dispassionately studied, there might be found the same complete identity of international interests as in ours.

And then, let us always remind ourselves of the nobility of our calling. I dare to claim for it that, among all the sciences, ours, in the pursuit and use of truth, offers the most complete and constant union of those three qualities which have the greatest charm for pure and active minds—novelty, utility, and charity. These three, which are sometimes in so lamentable disunion, as in the attractions of novelty without either utility or charity, are in our researches so combined that, unless by force or willful wrong, they hardly can be put asunder. And each of them is admirable in its kind. For in every search for truth we can not only exercise curiosity, and have the delight—the really elemental happiness—of watching the unveiling of a mystery, but, on the way to truth, if we look well round us, we shall see that we are passing wonders more than the eye or mind can fully apprehend. And as one of the perfections of Nature is that in all her works wonder is harmonized with utility, so is it with our science. In every truth attained there is utility either at hand or among the certainties of the future. And this utility is not selfish: it is not in any degree correlative with money-making; it may generally be estimated in the welfare of others better than in our own. Some of us may indeed make money and grow rich; but many of those that minister even to the follies and vices of mankind can make much more money than we. In all things costly and vainglorious they would far surpass us if we would compete with them. We had better not compete where wealth is the highest evidence of success; we can compete with the world in

the nobler ambition of being counted among the learned and the good who strive to make the future better and happier than the past. And to this we shall attain if we will remind ourselves that, as in every pursuit of knowledge there is the charm of novelty, and in every attainment of truth utility, so in every use of it there may be charity. I do not mean only the charity which is in hospitals or in the service of the poor, great as is the privilege of our calling in that we may be its chief ministers; but that wider charity which is practiced in a constant sympathy and gentleness, in patience and self-devotion. And it is surely fair to hold that, as in every search for knowledge we may strengthen our intellectual power, so in every practical employment of it we may, if we will, improve our moral nature; we may obey the whole law of Christian love, we may illustrate the highest induction of scientific philanthropy.

Let us, then, resolve to devote ourselves to the promotion of the whole science, art, and charity of medicine. Let this resolve be to us as a vow of brotherhood; and may God help us in our work!—*Nature.*

INCREASE AND MOVEMENT OF THE COLORED POPULATION.

By J. STAHL PATTERSON.

II. MOVEMENT.

FOR the purpose of comparing the movement of the colored population before and since emancipation, we begin with the following table, which shows the percentage of colored increase in each of the slave States for the last decade of slavery:

STATES.	1850.	1860.	Gain per cent.	STATES.	1850.	1860.	Gain per cent.
Texas	58,558	182,921	212·4	Tennessee	245,881	283,019	15·1
Arkansas	47,708	111,259	133·2	North Carolina	316,011	361,522	14·4
Florida	40,242	62,677	55·8	Kentucky	220,992	236,167	6·9
Mississippi	310,808	437,404	40·7	Delaware	20,363	21,627	6·2
Louisiana	262,271	350,373	33·6	South Carolina	393,944	412,320	4·7
Missouri	90,040	118,503	31·6	Virginia	526,861	548,907	4·2
Alabama	345,109	437,770	26·8	Dist. of Columb.	13,746	14,316	4·1
Georgia	384,613	465,698	21·1	Maryland	165,091	171,131	3·7

It will be observed that South Carolina and the border States added very little to their colored population during this decade. This was largely due to emigration, no doubt; and in most of these States this took opposite directions, part of it going southward by compulsion, and part of it northward by choice. Canada in a small way, and the new and great planting States of the South mainly, received the benefit of these tendencies of the colored movement.

The following table gives the colored increase of the same States

for the decade from 1860 to 1870, embracing the last three years of slavery and the first seven of freedom :

STATES.	1860.	1870.	Gain per cent.	STATES.	1860.	1870.	Gain per cent.
Dist. of Columb.	14,316	43,404	203·1	Delaware.....	21,627	22,794	5·4
Florida.....	62,677	91,689	46·3	Louisiana.....	350,373	364,210	4·0
Texas.....	182,921	253,475	38·6	Maryland.....	171,131	175,391	2·5
Georgia.....	465,698	545,142	17·1	Mississippi....	437,404	444,201	1·5
Tennessee.....	283,019	322,331	13·9	South Carolina.	412,320	415,814	0·9
Arkansas.....	111,259	122,169	9·8	Missouri.....	118,503	118,071	0·4 loss
Alabama.....	437,770	475,510	8·6	Va. and W. Va.	548,907	530,821	3·3 "
North Carolina..	361,052	391,650	8·3	Kentucky.....	236,167	222,210	5·9 "

The drift is mainly toward the two new States, Texas and Florida. A great change has come over the District of Columbia. From standing near the foot of the list in the previous table, it is now at the head. The freedmen found protection and encouragement, with a large demand for such labor as they are qualified to do, and hence they flocked to the District. The border States are worse off than during the previous decade, owing, no doubt, to the war and to the proximity of the old free States, in which the freedmen found more sympathy than among their former neighbors.

The following table shows the colored increase of the principal Northern States for the same decade, and shows what has become of a part of the freedmen :

STATES.	1860.	1870.	Gain per cent.	STATES.	1860.	1870.	Gain per cent.
Kansas.....	627	17,108	2,628·5	Massachusetts..	9,602	13,947	45·3
Iowa.....	1,069	5,762	439·0	Rhode Island..	3,952	4,980	26·0
Illinois.....	7,628	28,762	277·0	New Jersey....	25,336	30,658	21·0
Indiana.....	11,428	24,560	114·9	Pennsylvania..	56,949	65,294	14·7
Michigan.....	6,799	11,849	74·3	Connecticut....	8,627	9,668	12·0
Ohio.....	36,673	63,213	72·4	New York.....	49,005	52,081	6·3

The aggregate increase in these twelve States was from 217,092 to 327,882, or 51·0 per cent., being 41 per cent. more than the average increase of all the colored in the United States for the same period. Only one State (New York) fell below this average.

The following table shows the increase of the colored population in the former slave States for the last decade, 1870 to 1880 :

STATES.	1870.	1880.	Gain per cent.	STATES.	1870.	1880.	Gain per cent.
Arkansas.....	122,169	210,622	72·4	Louisiana.....	364,210	483,794	32·8
Texas.....	253,475	394,001	55·4	Alabama.....	475,510	600,249	26·2
Mississippi.....	444,201	650,337	46·4	Tennessee.....	322,331	402,991	25·0
South Carolina..	415,814	604,275	45·3	Virginia.....	512,841	631,754	23·2
West Virginia..	17,980	25,806	43.5	Missouri.....	118,071	145,046	22·8
Florida.....	91,689	125,464	36·8	Kentucky.....	222,210	271,461	22·2
Dist. of Columb.	43,404	59,378	36·8	Maryland.....	175,391	209,897	19·7
North Carolina..	391,650	531,351	35·7	Delaware.....	22,794	26,450	16·0
Georgia.....	545,142	724,685	32·9				

Usually, as population becomes more dense, its percentage of gain becomes less; but in the two Southern States, Mississippi and South Carolina, in which the colored population is densest and most largely outnumbering the white, the ratio of increase is among the greatest. Not even the principle of density, nor the terrors of the "Mississippi plan," appear to have exerted the least check upon the multiplication of the colored people in those States. They probably received some accessions from immigration, especially Mississippi, as Texas and Arkansas certainly did. The table indicates readily what States probably lost by emigration. The showing for South Carolina has been anomalous for the last three censuses, it having, like the border States, gained little during the seventh and eighth decades, but having gained enormously during the ninth, as shown by the last census, and yet in no State is the correctness of this census better assured than in South Carolina. If there be error it is in the previous census. The ratio of increase in seven of these States rises above the average for the colored population of the United States; North Carolina has the same ratio, while the others fall below it.

The following table gives the colored increase in twelve Northern States for the last decade:

STATES.	1870.	1880.	Gain per cent.	STATES.	1870.	1880.	Gain per cent.
Kansas.....	17,108	43,096	151·9	Rhode Island..	4,980	6,503	30·6
Iowa.....	5,762	9,443	63·9	New Jersey....	30,658	38,796	26·5
Illinois.....	28,762	46,248	60·8	Michigan.....	11,849	14,986	26·5
Indiana.....	24,560	38,998	58·8	Ohio.....	63,213	79,665	26·0
Massachusetts..	13,947	18,411	32·0	New York.....	52,081	64,969	24·7
Pennsylvania...	65,294	85,342	30·7	Connecticut....	9,668	11,428	18·2

During the decade the colored population in these twelve States increased from 327,882 to 458,185, being 39·9 per cent., a little above the ratio of increase for the entire colored population of the United States; but this was gained wholly in the first four States of the list, the percentage of gain in the remaining eight being about equal to the average gain of the white population in those States. The last two tables appear to indicate that the movement of the colored population is not great, but mainly toward the Southwestern States. And while only four of the Western States, Kansas, Iowa, Illinois, and Indiana, have received considerable accessions, the percentage of their gain being high, the aggregate number of immigrants northward is comparatively small. The last five States of the list seem to have lost a small portion of their colored population by emigration.

What is the law of colored migration? The colored man is actuated by the same motives in changing localities as any other man. Social attraction, sympathy, opportunity for paying employment, with facilities for reaching the new home—these determine the direction of his movement. Climate is, no doubt, a consideration which coöperates

with others in determining the general result, a warm climate being congenial to temperament and favorable to ease of living. In the South, the drift is to the new lands and the rich planting-regions; in the North, it is mainly to the accessible States in which employment is to be had. The tables of population by counties show that the colored people are very thoroughly distributed over the country, thinning out toward the North. In the same latitude the proportion of the colored population bears a very uniform relation to the number of whites. In tables giving the white and colored population of Northern States by counties, the adjacent columns, representing the two classes, indicate simply on their face this uniformity of relation. There are many exceptions, of course, as where, for example, in parts of New York, Pennsylvania, and New Jersey, there is a large proportion of Irish, the two races not harmonizing well together, since they are competitors for the same kinds of employment. There were 25 per cent. more colored in New York County in 1840 than in 1870; while in Hudson County, New Jersey, in which Jersey City is situated, there is far less than the usual proportion of the colored element. But the rule will hold in a general way, notwithstanding the exceptions by whatsoever caused.

It is not the habit of the colored people to look up a vacancy in some new State, and proceed to fill it with their own race. If they did they would have to be their own employers, and the prosperity of the community would be of their own making. On the contrary, they seem to find a place more congenial to their tastes and better adapted to their wants by the side of and among white people. Here they may get employment without making it for themselves. Instead, therefore, of dying out by the side of the white man under freedom, as has been supposed, they are really stronger to live there than they would be in a settlement of colored people alone. This is so necessarily where, as in the older States, capital is indispensable as the basis of employment. It would seem that, in the industrial aspects of the case, the white and colored man may be, under certain circumstances, the complement of each other.

What will be the direction of colored migration in the future? This will depend in part on the policy of States and of the General Government toward the colored people. Formerly it was a current speculation that the blacks would drift toward certain States in the South, which would pass under colored control in all respects, to the exclusion of the whites. This, however, is not likely to take place, except by interference of the General Government. If, under the pretext of a free ballot, the bayonet is resorted to by any party in power at Washington, and certain States in the South are again brought under the control of ignorant masses led by political adventurers, Southern society may be forced into a different form from that which now prevails. Under the continuance of such a policy, if it could be

maintained, certain States might become exclusively colored, and society therein sink toward a form of semi-barbarism. The white would eventually be driven out by political corruption, maladministration, and State bankruptcy. And let no man be deceived: if the native whites are compelled to abandon certain Southern localities on account of uninstructed colored predominance in local administration, the Yankee, or any other who is studious of thrift, will not take their place. Only a few sharpers, and the vultures in search of political carrion, will be found there. But this alternative of the "negro problem" is not likely to be adopted. Hardly any party is ready to go into history with such a policy, for, if it tripped, as it might, it would be bad for such party. It is the teaching of all history that those who have had freedom of self-rule have proved themselves competent to take it and hold it in spite of despots. This self-assertion is a necessary condition of freedom and its maintenance. There is no such thing as freedom under exotic tutelage. If a people who are numerically in the majority can only be secured in their political rights by national troops, then do such people illustrate political serfdom in becoming the tools of the party in power, and freedom becomes an abortion by the method used to secure it.

The problem, then, is to be determined on the presumption that local self-government in the South shall be in the hands of those who are competent to direct it; and that existing forces, under which the South has multiplied so rapidly in population during the last ten years, shall continue to operate.

Many of the planting-districts in the South contain already quite as large a colored population as is compatible with interest and comfort. This is thoroughly felt, if not clearly seen, by the colored people. They become the most dissatisfied with the situation, not where they are distributed among the whites in smaller numbers, but in districts where the colored population is greatest. Why so? Not on account of political terrorism by any means, but on account of the bad footing up at the close of the working-season. These are the places and this the reason which give rise to that recent phenomenon known as the "negro exodus." The tables indicate that there is emigration from most of the former border slave States. But the movement is individual, and not gregarious. It is undertaken with a rational view of what is to be gained by the change, much after the fashion of the whites, and it makes no noise in the newspapers as an "exodus." Among the simple-minded and impulsive masses farther South it is different. There it takes the form of a psychological epidemic, with only a vague and fanatical conception of what is ahead. We have only seen the beginning of this, perhaps, though the movement has its drawbacks. Not the most provident now leave the South; very generally, no doubt, the least so. Not the best hands come—often the worst. They have the old slave way, and the inaptitude for diversity

of labor, with characteristic indifference to their employers' interest. They are not generally satisfactory help. If they stay North, they live from hand to mouth, and when they die the town has to bury them. A few return to the warmer climate of the South where wants are less urgent and more easily supplied, and where the work to be done is simpler in form and better adapted to their habits. There is, therefore, a mild form of counter-exodus.

No doubt many portions even of the planting-regions in the older Southern States will admit of a still denser colored population. And while this continues to be the case no continuous heavy emigration is to be expected. But the filling-up process will go on, and, when there is crowding, relief will be had by emigration, if it is possible. The richest portions of the country South are breeding-lands, whence must flow increasing streams of colored migration, mainly to the westward, as the last census indicates. At any rate, they will flow in the direction of least resistance; and such are the forces which guide them, whether they flow westward or northward, that the people they bear become very thoroughly interdiffused among the whites. And while they are less thrifty than white people generally, all are not so. There are two distinct classes of colored economists. One is satisfied with dependence on others for employment; the other affects independent homes, and struggles to secure them, however humble. Some even acquire wealth. With wealth and independence will come greater respect. Gradually will the race-prejudice weaken. Now there are occasional marriages across the color-line; then they will be more frequent. This will accelerate the relative increase of the colored people, and the Caucasianizing of the colored race. Even now they are no longer negroes. One third has a large infusion of white blood, another third has less, but still some, and of the other third it would be difficult to find an assured specimen of pure African blood.

An English writer of distinction has found the solution of the American race question, in the blending of the white and colored elements, in the production of an improved type of man. We who are on the ground are generally skeptical as to the benefit thus to accrue; and it is not at all likely that amalgamation will ever be complete, under the reign of whatever physiological philosophy. Nature does not act in that thorough way; and philosophy does little to coerce Nature. Race prejudices and antipathies may abate, but they never wholly die out. Even after the plebeians and patricians might intermarry and the former be consuls, the patrician dames would relent none of their inherited scorn and antipathy for their plebeian rivals. Such prejudice is imbibed as unconsciously, but as surely, as nourishment from the mother's breast. It never ends. There will always be a colored race, of more uniform and lighter shade than at present, and always a white, even though branches of it perish in the fatal folds of luxury and dissipation. It will not end by amalgamation with the colored

race, nor change by absorbing it. Intermixture of the white and colored is destined, probably, to play a greater *rôle* than it now does; and this new race—for new it is—may greatly enlarge its proportion of numbers on American soil, but it is not to be expected that it will transcend in moral and intellectual elevation. It is probable that this mixed race which is forming in our country has greater capabilities than it generally gets credit for. In some respects its moral and social qualities may be quite as desirable in a race of mankind as the corresponding qualities in white men; but in intellect, in fertility of resource, in that which furthers progress and renders society and civilization exalted and refined, it is not likely that any compound with a fraction of Caucasian blood in it, will be equal to the Caucasian himself. In intellect, which, with Draper, we must regard as the leading and highest faculty of mind, it is not likely that any mixture of African blood, with all the advantages of development it may have, will ever equal the historical Teuton. And there is less to be hoped from the colored race in this country, because its progenitors on the African side are a low type even of Africans, as one of the race candidly admits (Rev. Edward W. Blyden, "a negro," "Fraser's Magazine"). Education may do a great deal, especially the education of practical life in connection with the more gifted Teuton; but with this spread of the colored element, if it should still continue, while it may itself experience a considerable degree of elevation, there must come a lowering, through this agency, of the average psychological level, and this can not take place without affecting the general tone of society. And it will so affect society, not only because of the relative gain of numbers, if that should be, but, paradoxical as it may seem, by virtue, also, of a certain degree of improvement which is above the lowest, but does not reach the highest, whereby the colored element will obtain a power in society, which, with fewer numbers and greater moral subordination, it did not before have. Then, indeed, will there be need of a "strong government," or, perhaps, it should rather be said, then will it be easy to establish a strong government.

ABOUT COMETS.

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THE study of astronomy reaches back to the very beginnings of history, and through all the ages the ablest intellects have been directed to the wellnigh impossible task of unraveling the celestial motions. The terrestrial observer not being located at the center of the motions of the solar system, the complexity arising from this com-

pounding of the motion of the observer with the motion of the planet observed rendered the problem very difficult.

Copernicus furnished the key, by showing that the sun and not the earth is the center of the solar system. Tycho Brahe soon followed, and furnished an extensive series of accurate observations that afforded Kepler the material upon which he based his studies that developed those immortal laws defining the forms of the orbits of the planets, the character of their motions, and the relation between the dimensions of their orbits and their periods of revolution.

It remained for Newton to discover the existence of the law of universal gravitation, of which Kepler's laws are an immediate sequence.

Thus the secrets of the motions of the planets were explained. But comets, those erratic visitants of our system, whose advent in olden time filled the mind with universal awe, were still an unfathomed mystery. Suddenly they would blaze out in the sky, and as suddenly pass out of sight, and no astronomer could tell whence they came or whither they went, or the laws which governed their motions.

Newton first showed that comets also were obedient to the attraction of gravitation. He demonstrated this fact by means of the comet of 1680. The orbit of this comet he found not to differ perceptibly from a parabola.

After Newton, Edmund Halley, from a careful study of the comets of 1531, 1607, and 1682, ventured the assertion that these were only different appearances of one and the same body, whose period of revolution was about seventy-five years. Halley, consequently, predicted a reappearance of this comet in 1759. This comet was shown to move in a very elongated ellipse. In accordance with prediction, reappearances of this comet occurred in 1759 and 1835.

Since the time of Newton all the comets which have come to view have been submitted to a careful study. To determine the orbit of any newly discovered member of our system, it is necessary that its direction in space from the earth at three dates, as nearly equidistant as may be, should be determined by observation.

The data for the problem are, then, as follows : the positions of the earth with reference to the sun at three different dates, and the positions of the heavenly body with reference to the earth at the same dates. The unknown elements which describe the character of the orbit and its position in space are as follows :

I. The mean longitude of the body at any convenient epoch.
II. The semi-major axis of the orbit.
III. The eccentricity of the orbit.
IV. The longitude of the perihelion.
V. The longitude of the ascending node.
VI. The inclination between the orbit-plane and the plane of the earth's orbit.

Of the above, I indicates the position of the body in the orbit at some definite time; II gives the greatest semi-diameter of the ellipse; III gives the ratio of the distance of the focus from the center divided by the semi-major axis; IV, with VI, gives the position in space of the greatest diameter of the ellipse; V gives the position of the line of intersection between the plane of the unknown orbit and the plane of the earth's orbit.

From II may be determined immediately the period of revolution by means of Kepler's law as follows: if a and a' are respectively the semi-major axis of the unknown orbit and the earth's orbit, and t and t' the respective periods of revolution, then we have from Kepler's law—

$$\frac{t^2}{a^3} = \frac{t'^2}{a'^3} \quad \text{and} \quad t = \left(\frac{a^3 t'^2}{a'^3}\right)^{\frac{1}{2}}.$$

If the eccentricity of the orbit is very large, the portion of the ellipse in the vicinity of the perihelion approximates to a parabola, which it becomes when the eccentricity equals unity.

As a matter of history, the great majority of comet orbits hitherto studied are either parabolas or are portions of excessively elongated ellipses, so as to be indistinguishable from parabolas, at least in the part of the orbit traversed during visibility. This portion of the orbit is always adjacent to the perihelion.

From the foregoing fact, and moreover because the computation of a parabolic orbit is much simpler, there being one less unknown quantity, preliminary comet orbits are always parabolic. Subsequent investigations show whether the comet deviates perceptibly from the parabola computed.

On October 10, 1880, Lewis Swift, of Rochester, New York, discovered a comet which has proved to be of peculiar interest. From its first discovery it has presented no brilliancy of appearance, for, during its period of visibility, a telescope of considerable power was necessary to observe it. Since this comet when in close proximity to the earth was very faint indeed, its dimensions must be quite moderate.

As soon after its apparition as the necessary observations of position were obtained, its parabolic elements were computed by several astronomers. After carefully comparing these elements with those of previous comets, Mr. S. C. Chandler, of Boston, remarked the striking similarity between them and those of Comet III of 1869. He immediately suspected them to be one and the same body, revolving in an elongated ellipse, having a period of eleven years, or a sub-multiple of eleven years.

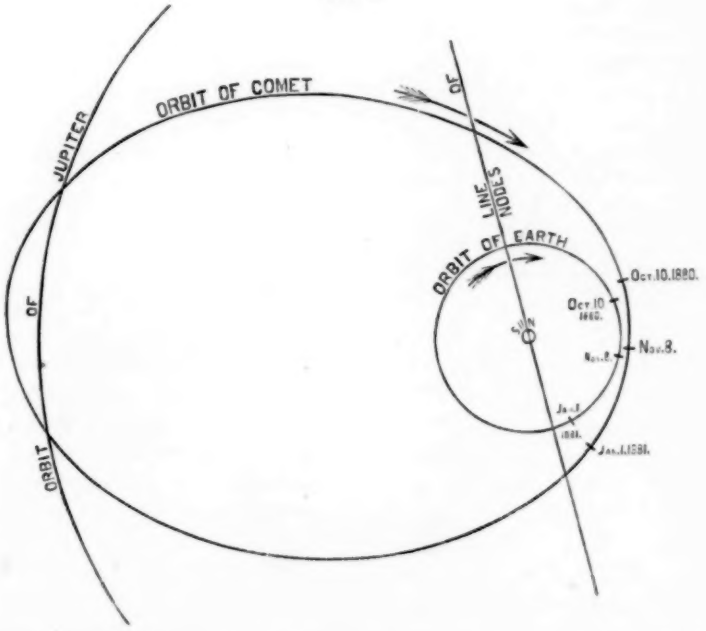
Mr. Chandler hereupon made some extended investigations, to determine which period was the more probable. He showed that the observed positions could be satisfied more closely with a period of five and one half years.

It seemed very desirable that elliptic elements should be determined for this comet without making any previous assumptions in reference to any of the elements ; this was undertaken independently by two astronomers of the United States Naval Observatory, each from different data. Professor Frisby made use of observations of October 25th, November 7th, and November 20th. Mr. Upton selected the following dates : October 25th, November 23d, and December 22d.

The results of these two computations agree very closely : the resulting period is only a few days less than six years. The inclination of the plane of the orbit to the plane of the ecliptic is about five and one half degrees.

To show more strikingly the remarkable situation of the comet's orbit with reference to the earth's orbit, the attention of the reader is directed to the accompanying diagram (Fig. 1), which, for the sake of

FIG. 1.



simplicity, shows the two orbits as if in one plane, when in reality the angle of inclination between them is about five and one half degrees. The line marked "line of nodes" is the line of their mutual intersection, the part of the comet's orbit in the vicinity of the perihelion being north of the plane of the ecliptic.

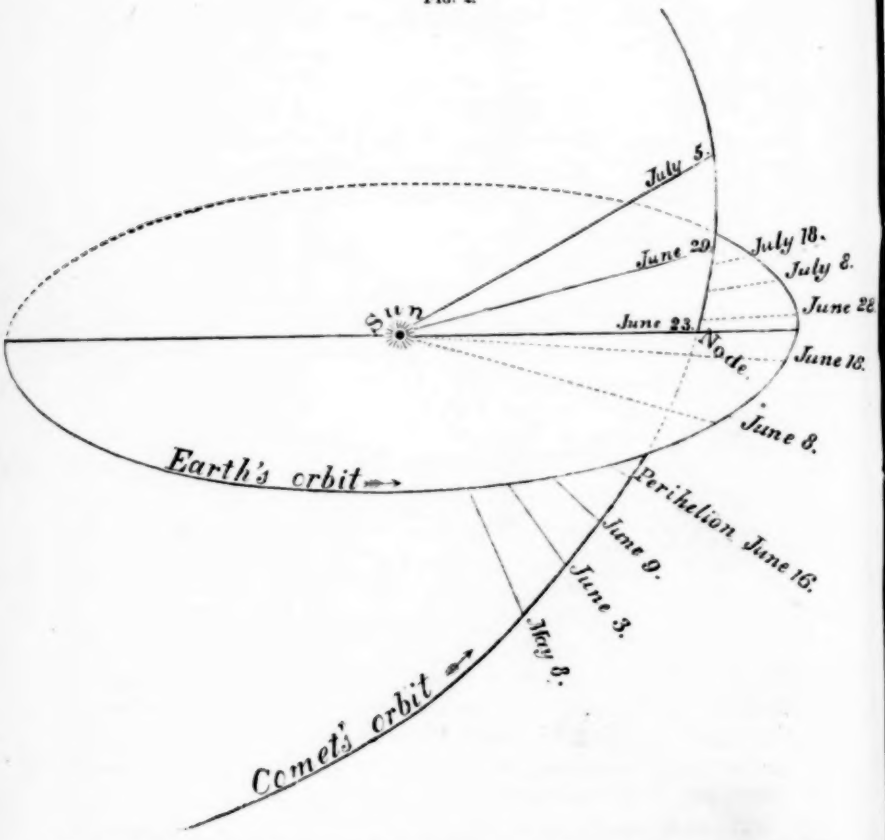
The relative situations of the earth and comet are shown by their positions in orbit at the date of discovery of the comet, October 10 ; the date of the perihelion passage, November 8, 1880, and January 1, 1881.

The nearest approach of the comet to the earth was about November 18, 1880, when it was distant from the earth 0·13 of the earth's distance from the sun. The period, as determined by Professor Frisby and Mr. Upton, is probably somewhat too large, owing to the uncertainty arising from the shortness of the arc of observation. The length of the period of revolution affords a reason for the fact that the comet escaped observation at its last return; since then it must have been in the direction of the sun.

It will be seen, from the drawing, that at aphelion the comet passes beyond the orbit of the planet Jupiter.

About the 22d of June last, a comet flashed into view which was unexpected as it was brilliant. It was seen with the unassisted eye by a multitude of persons in widely separated localities. Among the ear-

FIG. 2.



liest of those who discovered its presence in the northern sky was Mr. G. W. Simmons, of Boston, Massachusetts, who chanced to be in camp at Morales, Mexico. This gentleman first saw it on the morning of June 20th. It had, however, been discovered nearly one month earlier

by Mr. Tebbutt, of New South Wales, Australia, on May 22d. During the interval between these two dates it had moved northward through an arc of more than 60°, which rapid motion accounts for its sudden apparition in our northern sky.

The relative situation of the orbits of the comet and the earth will be best understood by the perspective view of a model of the two orbits constructed to scale (Fig. 2). This model was executed, from elements computed by Messrs. Chandler and Wendell, of Harvard College Observatory, by Ensign S. J. Brown, U. S. N., who kindly placed it at the service of the writer.

In this cut, the horizontal plane represents the position of the earth's orbit, and the plane cutting this at a large angle represents the plane of the comet's orbit. The comet moved from below, which is the southern side, up through the plane of the earth's orbit to the northern side. The dates indicate the positions of the earth and comet at different times in their respective orbits. It passed its perihelion point just before passing through the plane of the earth's orbit.

The orbit of the comet is inclined to the plane of the earth's orbit at an angle of 63°. Its perihelion distance is 0·77 of the earth's distance from the sun. It arrived at its perihelion June 16th, and was nearest the earth June 19th, when its distance from the earth was 0·28 of the earth's distance from the sun.

The nucleus attained fully the brightness of a first-magnitude star, and the length of the tail was variously estimated at from 20° to 30°. This comet is still faintly visible to the naked eye (August 22d).

At first it was suspected that this comet was identical with that of 1807, but later investigation disproved this supposition.

THE CONNECTION OF THE BIOLOGICAL SCIENCES WITH MEDICINE.*

By Professor T. H. HUXLEY.

THE great body of the theoretical and practical knowledge which has been accumulated by the labors of some eighty generations, since the dawn of scientific thought in Europe, has no collective English name to which an objection may not be raised; and I use the term "medicine" as that which is least likely to be misunderstood; though, as every one knows, the name is commonly applied, in a narrower sense, to one of the chief divisions of the totality of medical science.

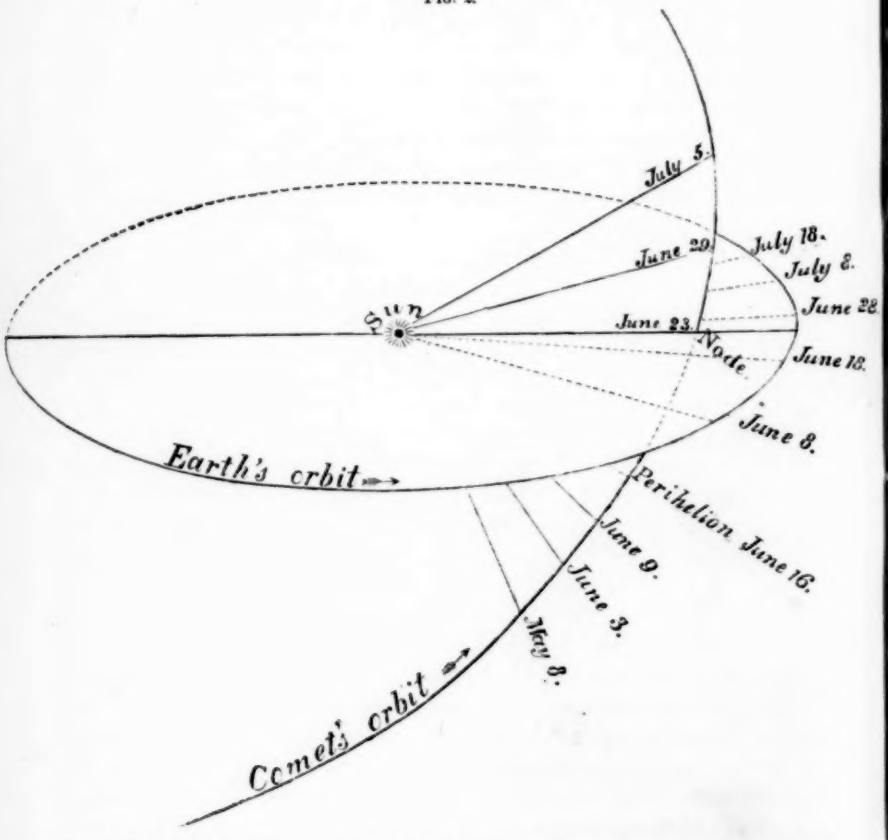
* Address at the International Medical Congress, by Professor T. H. Huxley, LL. D., Secretary to the Royal Society.

The nearest approach of the comet to the earth was about November 18, 1880, when it was distant from the earth 0·13 of the earth's distance from the sun. The period, as determined by Professor Frisby and Mr. Upton, is probably somewhat too large, owing to the uncertainty arising from the shortness of the arc of observation. The length of the period of revolution affords a reason for the fact that the comet escaped observation at its last return; since then it must have been in the direction of the sun.

It will be seen, from the drawing, that at aphelion the comet passes beyond the orbit of the planet Jupiter.

About the 22d of June last, a comet flashed into view which was unexpected as it was brilliant. It was seen with the unassisted eye by a multitude of persons in widely separated localities. Among the ear-

FIG. 2.



liest of those who discovered its presence in the northern sky was Mr. G. W. Simmons, of Boston, Massachusetts, who chanced to be in camp at Morales, Mexico. This gentleman first saw it on the morning of June 20th. It had, however, been discovered nearly one month earlier

by Mr. Tebbutt, of New South Wales, Australia, on May 22d. During the interval between these two dates it had moved northward through an arc of more than 60°, which rapid motion accounts for its sudden apparition in our northern sky.

The relative situation of the orbits of the comet and the earth will be best understood by the perspective view of a model of the two orbits constructed to scale (Fig. 2). This model was executed, from elements computed by Messrs. Chandler and Wendell, of Harvard College Observatory, by Ensign S. J. Brown, U. S. N., who kindly placed it at the service of the writer.

In this cut, the horizontal plane represents the position of the earth's orbit, and the plane cutting this at a large angle represents the plane of the comet's orbit. The comet moved from below, which is the southern side, up through the plane of the earth's orbit to the northern side. The dates indicate the positions of the earth and comet at different times in their respective orbits. It passed its perihelion point just before passing through the plane of the earth's orbit.

The orbit of the comet is inclined to the plane of the earth's orbit at an angle of 63°. Its perihelion distance is 0·77 of the earth's distance from the sun. It arrived at its perihelion June 16th, and was nearest the earth June 19th, when its distance from the earth was 0·28 of the earth's distance from the sun.

The nucleus attained fully the brightness of a first-magnitude star, and the length of the tail was variously estimated at from 20° to 30°. This comet is still faintly visible to the naked eye (August 22d).

At first it was suspected that this comet was identical with that of 1807, but later investigation disproved this supposition.

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THE great body of the theoretical and practical knowledge which has been accumulated by the labors of some eighty generations, since the dawn of scientific thought in Europe, has no collective English name to which an objection may not be raised; and I use the term "medicine" as that which is least likely to be misunderstood; though, as every one knows, the name is commonly applied, in a narrower sense, to one of the chief divisions of the totality of medical science.

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Taken in this broad sense, "medicine" not merely denotes a kind of knowledge, but it comprehends the various applications of that knowledge to the alleviation of the sufferings, the repair of the injuries, and the conservation of the health, of living beings. In fact, the practical aspect of medicine so far dominates over every other, that the "healing art" is one of its most widely received synonyms. It is so difficult to think of medicine otherwise than as something which is necessarily connected with curative treatment, that we are apt to forget that there must be, and is, such a thing as a pure science of medicine—a "pathology" which has no more necessary subservience to practical ends than has zoölogy or botany.

The logical connection between this purely scientific doctrine of disease, or pathology, and ordinary biology, is easily traced. Living matter is characterized by its innate tendency to exhibit a definite series of the morphological and physiological phenomena which constitute organization and life. Given a certain range of conditions, and these phenomena remain the same, within narrow limits, for each kind of living thing. They furnish the normal and typical characters of the species; and, as such, they are the subject-matter of ordinary biology.

Outside the range of these conditions, the normal course of the cycle of vital phenomena is disturbed; abnormal structure makes its appearance, or the proper character and mutual adjustment of the functions cease to be preserved. The extent and the importance of these deviations from the typical life may vary indefinitely. They may have no noticeable influence on the general well-being of the economy, or they may favor it. On the other hand, they may be of such a nature as to impede the activities of the organism, or even to involve its destruction.

In the first case, these perturbations are ranged under the wide and somewhat vague category of "variations"; in the second, they are called lesions, states of poisoning, or diseases; and, as morbid states, they lie within the province of pathology. No sharp line of demarkation can be drawn between the two classes of phenomena. No one can say where anatomical variations end and tumors begin, nor where modification of function, which may at first promote health, passes into disease. All that can be said is, that whatever change of structure or function is hurtful belongs to pathology. Hence it is obvious that pathology is a branch of biology; it is the morphology, the physiology, the distribution, the etiology of abnormal life.

However obvious this conclusion may be now, it was nowise apparent in the infancy of medicine. For it is a peculiarity of the physical sciences, that they are independent in proportion as they are imperfect; and it is only as they advance that the bonds which really unite them all become apparent. Astronomy had no manifest connection with terrestrial physics before the publication of the "Principia";

that of chemistry with physics is of still more modern revelation; that of physics and chemistry with physiology has been stoutly denied within the recollection of most of us, and perhaps still may be.

Or, to take a case which affords a closer parallel with that of medicine. Agriculture has been cultivated from the earliest times, and from a remote antiquity men have attained considerable practical skill in the cultivation of the useful plants, and have empirically established many scientific truths concerning the conditions under which they flourish. But it is within the memory of many of us that chemistry on the one hand and vegetable physiology on the other attained such a stage of development that they were able to furnish a sound basis for scientific agriculture. Similarly, medicine took its rise in the practical needs of mankind. At first, studied without reference to any other branch of knowledge, it long maintained, indeed still to some extent maintains, that independence. Historically, its connection with the biological sciences has been slowly established, and the full extent and intimacy of that connection are only now beginning to be apparent. I trust I have not been mistaken in supposing that an attempt to give a brief sketch of the steps by which a philosophical necessity has become an historical reality, may not be devoid of interest, possibly of instruction, to the members of this great Congress, profoundly interested as all are in the scientific development of medicine.

The history of medicine is more complete and fuller than that of any other science, except, perhaps, astronomy; and, if we follow back the long record as far as clear evidence lights us, we find ourselves taken to the early stages of the civilization of Greece. The oldest hospitals were the temples of Æsculapius; to these Asclepeia, always erected on healthy sites, hard by fresh springs and surrounded by shady groves, the sick and the maimed resorted to seek the aid of the god of health. Votive tablets or inscriptions recorded the symptoms, no less than the gratitude, of those who were healed; and, from these primitive clinical records, the half-priestly, half-philosophic caste of the Asclepiads compiled the data upon which the earliest generalizations of medicine, as an inductive science, were based.

In this state, pathology, like all the inductive sciences at their origin, was merely natural history; it registered the phenomena of diseases, classified them, and ventured upon a prognosis, wherever the observation of constant coexistences and sequences suggested a rational expectation of the like recurrence under similar circumstances.

Further than this it hardly went. In fact, in the then state of knowledge, and in the condition of philosophical speculation at that time, neither the causes of the morbid state nor the *rationale* of treatment were likely to be sought for as we seek for them now. The anger of a god was a sufficient reason for the existence of a malady, and a dream ample warrantee for therapeutic measures; that a physical

phenomenon must needs have a physical cause was not the implied or expressed axiom that it is to us moderns.

The great man whose name is inseparably connected with the foundation of medicine, Hippocrates, certainly knew very little, indeed practically nothing, of anatomy or physiology; and he would probably have been perplexed even to imagine the possibility of a connection between the zoölogical studies of his contemporary, Democritus, and medicine. Nevertheless, in so far as he, and those who worked before and after him in the same spirit, ascertained, as matters of experience, that a wound, or a luxation, or a fever, presented such and such symptoms, and that the return of the patient to health was facilitated by such and such measures, they established laws of nature, and began the construction of the science of pathology. All true science begins with empiricism—though all true science is such exactly, in so far as it strives to pass out of the empirical stage into that of the deduction of empirical from more general truths. Thus, it is not wonderful that the early physicians had little or nothing to do with the development of biological science; and, on the other hand, that the early biologists did not much concern themselves with medicine. There is nothing to show that the Asclepiads took any prominent share in the work of founding anatomy, physiology, zoölogy, and botany. Rather do these seem to have sprung from the early philosophers, who were essentially natural philosophers, animated by the characteristically Greek thirst for knowledge as such. Pythagoras, Alcmeon, Democritus, Diogenes of Apollonia, are all credited with anatomical and physiological investigation; and though Aristotle is said to have belonged to an Asclepiad family, and not improbably owed his taste for anatomical and zoölogical inquiries to the teachings of his father, the physician Nicomachus, the "Historia Animalium," and the treatise "De Partibus Animalium," are as free from any allusion to medicine as if they had issued from a modern biological laboratory.

It may be added that it is not easy to see in what way it could have benefited a physician of Alexander's time to know all that Aristotle knew on these subjects. His human anatomy was too rough to avail much in diagnosis, his physiology was too erroneous to supply data for pathological reasoning. But when the Alexandrian schools, with Erasistratus and Herophilus at their head, turned to account the opportunities for studying human structure, afforded to them by the Ptolemies, the value of the large amount of accurate knowledge thus obtained to the surgeon for his operations, and to the physician for his diagnosis of internal disorders, became obvious, and a connection was established between anatomy and medicine, which has ever become closer and closer. Since the revival of learning, surgery, medical diagnosis, and anatomy have gone hand in hand. Morgagni called his great work, "De sedibus et causis morborum per anatomen indagatis," and not only showed the way to search out the localities and the

causes of disease by anatomy, but himself traveled wonderfully far upon the road. Bichat, discriminating the grosser constituents of the organs and parts of the body one from another, pointed out the direction which modern research must take; until, at length, histology, a science of yesterday, as it seems to many of us, has carried the work of Morgagni as far as the microscope can take us, and has extended the realm of pathological anatomy to the limits of the invisible world.

Thanks to the intimate alliance of morphology with medicine, the natural history of disease has, at the present day, attained a high degree of perfection. Accurate regional anatomy has rendered practicable the exploration of the most hidden parts of the organism, and the determination during life of morbid changes in them; anatomical and histological *post-mortem* investigations have supplied physicians with a clear basis upon which to rest the classification of diseases, and with unerring tests of the accuracy or inaccuracy of their diagnoses.

If men could be satisfied with pure knowledge, the extreme precision with which in these days a sufferer may be told what is happening, and what is likely to happen, even in the most recondite parts of his bodily frame, should be as satisfactory to the patient as it is to the scientific pathologist who gives him the information. But I am afraid it is not; and even the practicing physician, while nowise underestimating the regulative value of accurate diagnosis, must often lament that so much of his knowledge rather prevents him from doing wrong, than helps him to do right.

A scorner of physic once said that nature and disease may be compared to two men fighting, the doctor to a blind man with a club, who strikes into the *mêlée*, sometimes hitting the disease, and sometimes hitting nature. The matter is not mended if you suppose the blind man's hearing to be so acute that he can register every stage of the struggle and pretty clearly predict how it will end. He had better not meddle at all, until his eyes are opened—until he can see the exact position of the antagonists, and make sure of the effect of his blows. But that which it behooves the physician to see, not indeed with his bodily eye, but with clear intellectual vision, is a process, and the chain of causation involved in that process. Disease, as we have seen, is a perturbation of the normal activities of a living body; and it is, and must remain, unintelligible, so long as we are ignorant of the nature of these normal activities. In other words, there could be no real science of pathology until the science of physiology had reached a degree of perfection unattained, and indeed unattainable, until quite recent times.

So far as medicine is concerned, I am not sure that physiology, such as it was down to the time of Harvey, might as well not have existed. Nay, it is perhaps no exaggeration to say that, within the memory of living men, justly renowned practitioners of medicine and surgery

knew less physiology than is now to be learned from the most elementary text-book; and, beyond a few broad facts, regarded what they did know as of extremely little practical importance. Nor am I disposed to blame them for this conclusion; physiology must be useless, or worse than useless, to pathology, so long as its fundamental conceptions are erroneous.

Harvey is often said to be the founder of modern physiology; and there can be no question that the elucidations of the function of the heart, of the nature of the pulse, and of the course of the blood, put forth in the ever-memorable little essay "De motu cordis," directly worked a revolution in men's views of the nature and of the concatenation of some of the most important physiological processes among the higher animals; while, indirectly, their influence was perhaps even more remarkable.

But, though Harvey made this signal and perennially important contribution to the physiology of the moderns, his general conception of vital processes was essentially identical with that of the ancients; and, in the "Exercitationes de generatione," and notably in the singular chapter "De calido innato," he shows himself a true son of Galen and of Aristotle.

For Harvey, the blood possesses powers superior to those of the elements; it is the seat of a soul which is not only vegetative but also sensitive and motor. The blood maintains and fashions all parts of the body, "*idque summa cum providentia et intellectu in finem certum agens, quasi ratiocinio quodam uteretur.*"

Here is the doctrine of the "pneuma," the product of the philosophical mold into which the animism of primitive men ran in Greece, in full force. Nor did its strength abate for long after Harvey's time. The same ingrained tendency of the human mind to suppose that a process is explained when it is ascribed to a power of which nothing is known except that it is the hypothetical agent of the process, gave rise in the next century to the animism of Stahl; and, later, to the doctrine of a vital principle, that "asylum ignorantiæ" of physiologists, which has so easily accounted for everything and explained nothing, down to our own times.

Now the essence of modern as contrasted with ancient physiological science, appears to me to lie in its antagonism to animistic hypotheses and animistic phraseology. It offers physical explanations of vital phenomena, or frankly confesses that it has none to offer. And, so far as I know, the first person who gave expression to this modern view of physiology, who was bold enough to enunciate the proposition that vital phenomena, like all the other phenomena of the physical world, are, in ultimate analysis, resolvable into matter and motion, was René Descartes.

The fifty-four years of life of this most original and powerful thinker are widely overlapped, on both sides, by the eighty of Harvey, who

survived his younger contemporary by seven years, and takes pleasure in acknowledging the French philosopher's appreciation of his great discovery.

In fact, Descartes accepted the doctrine of the circulation as propounded by "Hervæus, médecin d'Angleterre," and gave a full account of it in his first work, the famous "Discours de la Méthode," which was published in 1637, only nine years after the exercitation "De motu cordis"; and, though differing from Harvey in some important points (in which, it may be noted, in passing, Descartes was wrong and Harvey right), he always speaks of him with great respect. And so important does the subject seem to Descartes, that he returns to it in the "Traité des Passions" and in the "Traité de l'Homme."

It is easy to see that Harvey's work must have had a peculiar significance for the subtile thinker, to whom we owe both the spiritualistic and the materialistic philosophies of modern times. It was in the very year of its publication, 1628, that Descartes withdrew into that life of solitary investigation and meditation of which his philosophy was the fruit. And, as the course of his speculations led him to establish an absolute distinction of nature between the material and the mental worlds, he was logically compelled to seek for the explanation of the phenomena of the material world within itself; and, having allotted the realm of thought to the soul, to see nothing but extension and motion in the rest of nature. Descartes uses "thought" as the equivalent of our modern term "consciousness." Thought is the function of the soul, and its only function. Our natural heat and all the movements of the body, says he, do not depend on the soul. Death does not take place from any fault of the soul, but only because some of the principal parts of the body become corrupted. The body of a living man differs from that of a dead man in the same way as a watch or other automaton (that is to say, a machine which moves of itself), when it is wound up and has in itself the physical principle of the movements which the mechanism is adapted to perform, differs from the same watch or other machine when it is broken, and the physical principle of its movement no longer exists. All the actions which are common to us and the lower animals depend only on the conformation of our organs and the course which the animal spirits take in the brain, the nerves, and the muscles; in the same way as the movement of a watch is produced by nothing but the force of its spring and the figure of its wheels and other parts.

Descartes's "Treatise on Man" is a sketch of human physiology, in which a bold attempt is made to explain all the phenomena of life, except those of consciousness, by physical reasonings. To a mind turned in this direction, Harvey's exposition of the heart and vessels as an hydraulic mechanism must have been supremely welcome.

Descartes was not a mere philosophical theorist, but a hard-working dissector and experimenter, and he held the strongest opinion respect-

ing the practical value of the new conception which he was introducing. He speaks of the importance of preserving health, and of the dependence of the mind on the body being so close that perhaps the only way of making men wiser and better than they are is to be sought in medical science. "It is true," says he, "that as medicine is now practiced, it contains little that is very useful; but, without any desire to depreciate, I am sure that there is no one, even among professional men, who will not declare that all we know is very little as compared with that which remains to be known; and that we might escape an infinity of diseases of the mind, no less than of the body, and even perhaps from the weakness of old age, if we had sufficient knowledge of their causes, and of all the remedies with which nature has provided us." * So strongly impressed was Descartes with this, that he resolved to spend the rest of his life in trying to acquire such a knowledge of nature as would lead to the construction of a better medical doctrine.† The anti-Cartesians found material for cheap ridicule in these aspirations of the philosopher: and it is almost needless to say that, in the thirteen years which elapsed between the publication of the "Discours" and the death of Descartes, he did not contribute much to their realization. But, for the next century, all progress in physiology took place along the lines which Descartes laid down.

The greatest physiological and pathological work of the seventeenth century, Borelli's treatise "De motu animalium," is, to all intents and purposes, a development of Descartes's fundamental conception; and the same may be said of the physiology and pathology of Boerhaave, whose authority dominated in the medical world of the first half of the eighteenth century.

With the origin of modern chemistry and of electrical science in the latter half of the eighteenth century, aids in the analysis of the phenomena of life, of which Descartes could not have dreamed, were offered to the physiologist. And the greater part of the gigantic progress which has been made in the present century, is a justification of the prevision of Descartes. For it consists, essentially, in a more and more complete resolution of the grosser organs of the living body into physico-chemical mechanisms.

"I shall try to explain our whole bodily machinery in such a way that it will be no more necessary for us to suppose that the soul produces such movements as are not voluntary than it is to think that there is in a clock a soul which causes it to show the hours." ‡ These words of Descartes might be appropriately taken as a motto by the author of any modern treatise on physiology.

But, though, as I think, there is no doubt that Descartes was the first to propound the fundamental conception of the living body as a physical mechanism, which is the distinctive feature of modern as

* "Discours de la Méthode," 6e partie, Ed. Cousin, p. 193. † Ibid., pp. 193, 211.

‡ "De la Formation du Fœtus."

contrasted with ancient physiology, he was misled by the natural temptation to carry out, in all its details, a parallel between the machines with which he was familiar, such as clocks and pieces of hydraulic apparatus, and the living machine. In all such machines there is a central source of power, and the parts of the machine are merely passive distributors of that power. The Cartesian school conceived of the living body as a machine of this kind; and herein they might have learned from Galen, who, whatever ill use he may have made of the doctrine of "natural faculties," nevertheless had the great merit of perceiving that local forces play a great part in physiology.

The same truth was recognized by Glisson, but it was first prominently brought forward in the Hallerian doctrine of the "vis insita" of muscles. If muscle can contract without nerve, there is an end of the Cartesian mechanical explanation of its contraction by the influx of animal spirits.

The discoveries of Trembley tended in the same direction. In the fresh-water *Hydra* no trace was to be found of that complicated machinery upon which the performance of the functions in the higher animals was supposed to depend. And yet the hydra moved, fed, grew, multiplied, and its fragments exhibited all the powers of the whole. And, finally, the work of Caspar F. Wolff,* by demonstrating the fact that the growth and development of both plants and animals take place antecedently to the existence of their grosser organs, and are, in fact, the causes and not the consequences of organization (as then understood), sapped the foundations of the Cartesian physiology as a complete expression of vital phenomena.

For Wolff, the physical basis of life is a fluid, possessed of a "vis essentialis" and a "solidescibilitas," in virtue of which it gives rise to organization; and, as he points out, this conclusion strikes at the root of the whole iatro-mechanical system.

In this country the great authority of John Hunter exerted a similar influence; though it must be admitted that the two sibylline utterances which are the outcome of Hunter's struggles to define his conceptions are often susceptible of more than one interpretation. Nevertheless, on some points Hunter is clear enough. For example, he is of opinion that "spirit is only a property of matter" ("Introduction to Natural History," p. 6), he is prepared to renounce animism (*loc. cit.*, p. 8), and his conception of life is so completely physical that he thinks of it as something which can exist in a state of combination in the food. "The aliment we take in has in it, in a fixed state, the real life; and this does not become active until it has got into the lungs; for there it is freed from its prison" ("Observations on Physiology," p. 113). He also thinks that "it is more in accord with the general principles of the animal machine to suppose that none of its effects are produced from any mechanical principle what-

* "Theoria Generationis," 1759.

ever; and that every effect is produced from an action in the part; which action is produced by a stimulus upon the part which acts, or upon some other part with which this part sympathizes so as to take up the whole action" (*loc. cit.*, p. 152).

And Hunter is as clear as Wolff, with whose work he was probably unacquainted, that "whatever life is, it most certainly does not depend upon structure or organization" (*loc. cit.*, p. 114).

Of course, it is impossible that Hunter could have intended to deny the existence of purely mechanical operations in the animal body. But while, with Borelli and Boerhaave, he looked upon absorption, nutrition, and secretion as operations effected by means of the small vessels, he differed from the mechanical physiologists, who regarded these operations as the result of the mechanical properties of the small vessels, such as the size, form, and disposition of their canals and apertures. Hunter, on the contrary, considers them to be the effect of properties of these vessels which are not mechanical, but vital. "The vessels," says he, "have more of the polypus in them than any other part of the body," and he talks of the "living and sensitive principles of the arteries," and even of the "dispositions or feelings of the arteries. . . . When the blood is good and genuine the sensations of the arteries, or the dispositions for sensation, are agreeable. . . . It is then they dispose of the blood to the best advantage, increasing the growth of the whole, supplying any losses, keeping up a due succession, etc." (*loc. cit.*, p. 133).

If we follow Hunter's conceptions to their logical issue, the life of one of the higher animals is essentially the sum of the lives of all the vessels, each of which is a sort of physiological unit, answering to a polyp; and, as health is the result of the normal "action of the vessels," so is disease an effect of their abnormal action. Hunter thus stands in thought, as in time, midway between Borelli on the one hand and Bichat on the other.

The acute founder of general anatomy, in fact, outdoes Hunter in his desire to exclude physical reasonings from the realm of life. Except in the interpretation of the action of the sense-organs, he will not allow physics to have anything to do with physiology.

"To apply the physical sciences to physiology is to explain the phenomena of living bodies by the laws of inert bodies. Now, this is a false principle, hence all its consequences are marked with the same stamp. Let us leave to chemistry its affinity, to physics its elasticity and its gravity. Let us invoke for physiology only sensibility and contractility." *

Of all the unfortunate dicta of men of eminent ability this seems one of the most unhappy, when we think of what the application of the methods and the data of physics and chemistry has done toward bringing physiology into its present state. It is not too much to say

* "Anatomie Générale," t. i, p. 54.

that one half of a modern text-book of physiology consists of applied physics and chemistry; and that it is exactly in the exploration of the phenomena of sensibility and contractility that physics and chemistry have exerted the most potent influence.

Nevertheless, Bichat rendered a solid service to physiological progress by insisting upon the fact that what we call life, in one of the higher animals, is not an indivisible unitary archæus dominating, from its central seat, the parts of the organism, but a compound result of the synthesis of the separate lives of those parts.

"All animals," says he, "are assemblages of different organs, each of which performs its function and concurs, after its fashion, in the preservation of the whole. They are so many special machines in the general machine which constitutes the individual. But each of these special machines is itself compounded of many tissues of very different natures, which in truth constitute the elements of those organs" (*loc. cit.*, lxxix). "The conception of a proper vitality is applicable only to these simple tissues, and not to the organs themselves" (*loc. cit.*, lxxxiv).

And Bichat proceeds to make the obvious application of this doctrine of synthetic life, if I may so call it, to pathology. Since diseases are only alterations of vital properties, and the properties of each tissue are distinct from those of the rest, it is evident that the diseases of each tissue must be different from those of the rest. Therefore, in any organ composed of different tissues, one may be diseased and the other remain healthy; and this is what happens in most cases (*loc. cit.*, lxxxv).

In a spirit of true prophecy, Bichat says, "We have arrived at an epoch, in which pathological anatomy should start afresh." For as the analysis of the organs had led him to the tissues, as the physiological units of the organism; so, in a succeeding generation, the analysis of the tissues led to the cell as the physiological element of the tissues. The contemporaneous study of development brought out the same result, and the zoölogists and botanists exploring the simplest and the lowest forms of animated beings confirmed the great induction of the cell theory. Thus the apparently opposed views, which have been battling with one another ever since the middle of the last century, have proved to be each half the truth.

The proposition of Descartes that the body of a living man is a machine, the actions of which are explicable by the known laws of matter and motion, is unquestionably largely true. But it is also true that the living body is a synthesis of innumerable physiological elements, each of which may nearly be described, in Wolff's words, as a fluid possessed of a "vis essentialis," and a "solidescibilitas"; or, in modern phrase, as protoplasm susceptible of structural metamorphosis and functional metabolism; and that the only machinery, in the precise sense in which the Cartesian school understood mechanism, is that

which coördinates and regulates these physiological units into an organic whole.

In fact, the body is a machine of the nature of an army, not of that of a watch, or of an hydraulic apparatus. Of this army, each cell is a soldier, an organ a brigade, the central nervous system headquarters and field telegraph, the alimentary and circulatory system the commissariat. Losses are made good by recruits born in camp, and the life of the individual is a campaign, conducted successfully for a number of years, but with certain defeat in the long-run.

The efficacy of an army, at any given moment, depends on the health of the individual soldier, and on the perfection of the machinery by which he is led and brought into action at the proper time; and, therefore, if the analogy holds good, there can be only two kinds of diseases, the one dependent on abnormal states of the physiological units, the other on perturbation of their coördinating and alimentative machinery.

Hence, the establishment of the cell theory, in normal biology, was swiftly followed by a "cellular pathology," as its logical counterpart. I need not remind you how great an instrument of investigation this doctrine has proved in the hands of the man of genius, to whom its development is due; and who would probably be the last to forget that abnormal conditions of the coördinative and distributive machinery of the body are no less important factors of disease.

Henceforward, as it appears to me, the connection of medicine with the biological sciences is clearly defined. Pure pathology is that branch of biology which defines the particular perturbation of cell-life, or of the coördinating machinery, or of both, on which the phenomena of disease depend.

Those who are conversant with the present state of biology will hardly hesitate to admit that the conception of the life of one of the higher animals as the summation of the lives of a cell aggregate, brought into harmonious action by a coördinative machinery formed by some of these cells, constitutes a permanent acquisition of physiological science. But the last form of the battle between the animistic and the physical views of life is seen in the contention whether the physical analysis of vital phenomena can be carried beyond this point or not.

There are some to whom living protoplasm is a substance even such as Harvey conceived the blood to be, "*summa cum providentia et intellectu in finem certum agens, quasi ratiocinio quodam*"; and who look, with as little favor as Bichat did, upon any attempt to apply the principles and the methods of physics and chemistry to the investigation of the vital processes of growth, metabolism, and contractility. They stand upon the ancient ways; only, in accordance with that progress toward democracy which a great political writer has declared to be the fatal characteristic of modern times, they substitute a repub-

lic formed by a few billion "animulæ" for the monarchy of the all-pervading "anima."

Others, on the contrary, supported by a robust faith in the universal applicability of the principles laid down by Descartes, and seeing that the actions called "vital" are, so far as we have any means of knowing, nothing but changes of place of particles of matter, look to molecular physics to achieve the analysis of the living protoplasm itself into a molecular mechanism. If there is any truth in the received doctrines of physics, that contrast between living and inert matter, on which Bichat lays so much stress, does not exist. In nature, nothing is at rest, nothing is amorphous; the simplest particle of that which men in their blindness are pleased to call "brute matter" is a vast aggregate of molecular mechanisms, performing complicated movements of immense rapidity and sensitively adjusting themselves to every change in the surrounding world. Living matter differs from other matter in degree and not in kind; the microcosm repeats the macrocosm; and one chain of causation connects the nebulous original of suns and planetary systems with the protoplasmic foundation of life and organization.

From this point of view, pathology is the analogue of the theory of perturbations in astronomy; and therapeutics resolves itself into the discovery of the means by which a system of forces competent to eliminate any given perturbation may be introduced into the economy. And, as pathology bases itself upon normal physiology, so therapeutics rests upon pharmacology; which is, strictly speaking, a part of the great biological topic of the influence of conditions on the living organism and has no scientific foundation apart from physiology.

It appears to me that there is no more hopeful indication of the progress of medicine toward the ideal of Descartes than is to be derived from a comparison of the state of pharmacology, at the present day, with that which existed forty years ago. If we consider the knowledge positively acquired, in this short time, of the *modus operandi* of urari, of atropia, of physostigmin, of veratria, of casca, of strychnia, of bromide of potassium, of phosphorus, there can surely be no ground for doubting that, sooner or later, the pharmacologist will supply the physician with the means of affecting, in any desired sense, the functions of any physiological element of the body. It will, in short, become possible to introduce into the economy a molecular mechanism which, like a very cunningly contrived torpedo, shall find its way to some particular group of living elements, and cause an explosion among them, leaving the rest untouched.

The search for the explanation of diseased states in modified cell-life; the discovery of the important part played by parasitic organisms in the etiology of disease; the elucidation of the action of medicaments by the methods and the data of experimental physiology; appear to me to be the greatest steps which have ever been made

toward the establishment of medicine on a scientific basis. I need hardly say they could not have been made except for the advance of normal biology.

There can be no question, then, as to the nature or the value of the connection between medicine and the biological sciences. There can be no doubt that the future of pathology and of therapeutics, and therefore that of practical medicine, depends upon the extent to which those who occupy themselves with these subjects are trained in the methods and impregnated with the fundamental truths of biology.

And, in conclusion, I venture to suggest that the collective sagacity of this congress could occupy itself with no more important question than with this: How is medical education to be arranged, so that, without entangling the student in those details of the systematist which are valueless to him, he may be enabled to obtain a firm grasp of the great truths respecting animal and vegetable life, without which, notwithstanding all the progress of scientific medicine, he will still find himself an empiric?

PROGRESS IN THE MANUFACTURE OF STEEL.*

By Professor A. K. HUNTINGTON.

IMPROVEMENTS in the arts and sciences have gradually modified the methods of producing iron and steel, and, in their turn, the arts and sciences have felt the reaction; for all improvements in the manufacture of iron and steel have consisted, not so much in the production of a better quality of the article, as in the cheapening of production by the application of the principles indicated by the progress of science, and by the use of superior machinery. The direct result of this cheapening has been to extend the applications of the products in the arts.

The discovery of steel appears to have naturally followed that of the means of reducing iron from its ore. In all primitive methods of iron-smelting, steel, in more or less quantity, is inevitably produced. Such methods have been carried on in India and Africa from time immemorial to the present day. A furnace of a similar primitive character has, for several centuries, been employed in Catalonia, in Spain.

In working this furnace, the ore is crushed by the hammer, and divided by sifting into lumps (*mine*) and very coarse powder (*greillade*). The furnace being still red-hot from the last operation, it is filled with charcoal nearly to the *tuyère*, the hearth is then divided at a point about two thirds distance from the tuyère into two parts by a broad shovel; on the blast-side a further quantity of char-

* Abridged from an address delivered before the London Society of Arts.

coal is added, while the coal on the other side having been rammed down firm, ore is added, so as to fill that part of the furnace; on this is placed moistened charcoal-dust, except at the top. A good blast is then turned on, and, if the whole is in proper order, jets of blue flame at once issue from the uncovered portion of the ore.

During the whole of the process, at short intervals, greillade and charcoal are added, and well moistened with water, to prevent too rapid combustion. After about two hours from the commencement, the wall of mine, i. e.—ore in lumps—is pushed well forward under the tuyère, and more mine is thrown into the space thus made; this part of the process is also subsequently repeated at intervals, until sufficient has been added to form a lump of iron or *massé* of the required size. From time to time slag is removed by opening the tap-hole. At the completion of the process, a mass of metal is obtained weighing about three hundred-weight, which invariably consists partly of soft iron, and partly of steely iron and steel.

The ore on one side of the furnace being in lumps, the hot carbonic oxide generated by the action of the blast on the charcoal is able to pass freely through its mass, reducing it, after the water has been driven off by heat, to metallic iron. At the same time the ore becomes impregnated with carbon, derived from the decomposition of the gases with which it is charged. The greillade on the other side is much richer in silica than the larger pieces, and from this it results that the quantity of slag will vary with the greillade added. It is always very rich in oxide of iron. It appears that in this process, carburized iron is produced by the gradual reduction and fusion of the lumps of ore, and this, coming in contact at the bottom of the furnace with slag, very rich in oxide of iron, the carbon of the one combines with the oxygen of the other, and the result is that iron containing more or less carbon is produced, according as much or little oxide was present.

In order that steel may be produced by this process, every precaution is taken to cause as much carburization as possible; the unavoidable presence of oxide of iron in the slag, and the low temperature, effectually preventing the formation of cast-iron; the former, indeed, making it very difficult to obtain steel.

Rightly looked at, this process explains how steel was first obtained, and what the essential conditions are in its production. When, owing to the increased size of blast-furnaces, and the consequent increase of temperature, cast-iron became the only product, it naturally followed that this substance should be treated with a view to the production of steel. This was first effected in the refining hearth, and formed an important industry in Styria, Carinthia, the Tyrol, and other places, in some of which it is still carried on. The operation was conducted in a finery, similar in construction to those employed in the production of iron—in fact, iron and steel are often produced

alternately in the same finery. This furnace, in its simplest form, consists essentially of a shallow quadrangular hearth, formed of cast-iron plates. In one side is a tuyère, inclined at an angle of 10° to 15°. The bottom is kept covered with a layer of charcoal. In the Siegen district, a piece of pig-iron, weighing fifty to sixty pounds, is placed on the hearth, having been previously heated; the hearth is then three parts filled with burning charcoal; on it is placed a portion of the cake produced in the last operation, which has been kept hot in burning charcoal, at the back of the furnace. The remainder of the hearth is then filled up with charcoal. The other six or seven pieces into which the last cake was divided are placed on the top. In this process, the production of steel and the reheating of that obtained in the last operation, preparatory to working it under the hammer, are conducted together. The blast is turned on. The piece of pig-iron forms into a pasty mass; cinder, rich in oxide of iron, produced in the latter part of the preceding operation, is then thrown in; a second piece of pig-iron, weighing about one hundred pounds, is added, and afterward four or five pieces of *spiegeleisen* (cast-iron, containing manganese), weighing each about a hundred pounds, are successively added. If the metal is found to be too much decarburized, more spiegel is added. In this process, as in the Catalan, it is impossible to obtain a homogeneous product. The principle in both is essentially the same, viz., decarburization by oxide of iron. In this process, as in every other process for the production of steel, manganese is used with great advantage—an advantage which arises from its power of replacing iron in the slag and of forming a slag that is more liquid than one containing iron alone.

The essential difference between the finery and the puddling process consists in the use of a reverberatory furnace, the manipulation of the metal and the regulation of the temperature being thereby greatly facilitated. The decarburization is effected by the addition of oxide of iron produced during rolling, and partially by the air which enters the furnace as the metal melts slowly down; manganese is added during the process. It is important that the temperature should be kept low. It is difficult to weld this steel perfectly, because, probably, the temperature at which it has to be worked is too low to make the cinder sufficiently liquid to enable it to be squeezed out under the hammer to the same extent that it is in the case of malleable iron. This difficulty has, however, been got over by completely fusing the steel before working it, so as to enable the slag to separate completely. In this form metal manufactured by this process has been largely used by Krupp.

The principle which regulates the production of steel by these methods is taken advantage of in the Uchatius process, in which pig-iron is first granulated by running it while molten into cold water. The granulated metal is then mixed with about twenty per cent. of roasted

spathic ore, crushed fine ; the mixture, to which a little flux has been added, if necessary, is then fused in clay crucibles. If very soft steel is required, some wrought-iron scrap is added.

Lastly, in this category we have a process which consists in heating cast-iron, but not so as to soften it, in oxide of iron, in the form of ore or iron-scale. In this way partial, or even total, decarburization of the metal can be produced at will.

So far the difference between iron and steel has seemed to be merely one of degree, depending on the amount of carburization. The methods we have considered are, in fact, only modifications of those practiced for the production of malleable iron. We will now consider the different processes that have for their object to impart a certain amount of carbon to malleable iron. The Hindoos have practiced one of them from time immemorial. They place in unbaked-clay crucibles, of the capacity of a pint, a piece of malleable iron, some chopped wood, and a few leaves of certain plants ; the top of the crucible is then closed with clay, and the whole well dried near a fire. A number of these crucibles are then strongly heated for about four hours in a cavity in the ground, by means of charcoal and a blast of air forced in by a bellows. There is some reason to believe that an excess of carbon, over that required to produce the hardest steel, has to be added, in order to fuse the metal at the temperature which can be commanded in these furnaces. Before being drawn out into bars, the cakes of metal obtained in this way are exposed in a charcoal-fire during several hours to a temperature a little below their melting-point, the blast of air playing upon them during the time. The object of this is, doubtless, to remove the excess of carbon.

In 1800 a patent was taken out by David Mushet for a process in every respect analogous to that just referred to. He appears, however, to have applied it to the manufacture of a metal low in carbon, and therefore intermediate between iron and steel, partaking in a certain degree of the properties of both.

In another method referred to by Biringuccio, in 1540, steel was produced by keeping malleable iron in molten cast-iron until it became pasty, and on examination was found to possess the properties of steel. In connection with the theory of steel manufacture this process is of great interest. It shows that iron in a strongly heated condition is capable of absorbing carbon by direct contact, unless we suppose that the carburization is effected by dissolved gases, which is possible.

In the cementation process, which was well described by Réaumur, in 1722, bars of iron are kept at a glowing red heat, surrounded with charcoal in boxes, into which the air is prevented from entering. The operation lasts from seven to ten days, according to the quality of steel required. These bars are never uniformly carburized, and, besides, they contain cinder, as the metal has never been fused. The

process had been a long time in use, however, before it occurred to any one to fuse the steel and make it homogeneous. This was done by Huntsman, about 1760.

By all the processes we have so far reviewed, good steel could be produced, but only in small quantity and at great expense. The applications of steel were, in consequence, very limited; in fact, practically, its use was confined to implements with a cutting edge.

In 1845 Heath patented a process which, had it been successful, would have given him the power of producing steel in quantity. He proposed to melt scrap-iron in a bath of molten pig iron in a reverberatory furnace heated by jets of gas. There were two conditions wanting in this method, which caused it to be a failure, viz., a sufficiently high temperature, and the power easily to regulate the character of the gases employed. Nevertheless, in this suggestion is to be found the germ of one of the two most important processes of the present day.

The dominant idea in treating cast-iron for steel had always been to refine the metal by the action of atmospheric air, and this was effected by causing a current of air to impinge upon the surface of the metal, by means either of a blowing apparatus or the drawing action of a chimney-stack. What more natural than that it should occur to some one to refine iron by blowing air into it, instead of merely on to its surface? We find that this idea did occur to several persons, widely separated, in the year 1855.

In this year a patent was taken out by John Gilbert Martien for refining iron, by forcing air through it as it flowed from the blast-furnace, or cupola, along runners to the puddling-furnace. The process, as detailed in the patent, was impracticable, and showed internal evidence of not having been worked out on a manufacturing scale. Just after this patent was taken out, we find George Parry, of the Ebbw Vale Works, making the experiment of forcing air through molten cast-iron, on the bed of a reverberatory furnace, by means of perforated pipes imbedded in the fire-clay bottom. Vigorous action is said to have taken place; but the metal, through an accident, escaped from the furnace, and the further trial of the process was discouraged by the managing director. Two or three months after these experiments, Henry Bessemer took out his now celebrated patent for the production of cast-steel by blowing air through molten cast-iron; it should be clearly borne in mind that he had been, for a considerable time previously, engaged in experiments on the subject. He first carried out his process in crucibles, placed in furnaces, and so arranged that the contents could be tapped from the bottom into molds. Steam or air, either separately or together, and by preference raised to a high temperature, was forced down into the crucible through a pipe. The patent goes on to state that steam cools the metal, but air causes a rapid increase in its temperature, and it passes from a red to

an intense white heat. Bessemer at first used extraneous heat to start the process, if not, indeed, during its progress, which shows that he was not then aware that the heat created by merely blowing in air would be sufficient. In his next patent he dispensed with the furnace around the crucible, and, instead of tapping the crucible from the bottom, he mounted it on trunnions, and, by tipping it up by machinery, poured the contents from the mouth. This apparatus is essentially the same as that used at the present day. It was soon found that, to produce steel by this process which would work properly, manganese, if not originally present, would have to be added. In the absence of manganese, sulphur and oxygen, in anything more than very minute quantities, make the steel crumble when worked at a red heat; it is said to be "red short." In the case of the oxygen, the manganese combines with it, and passes it into the slag; but with sulphur the reaction is different; its injurious effect is simply counteracted by the manganese: it is not removed from the steel. At first manganese was only employed in the form of spiegeleisen; but this use was liable to the difficulty that if enough spiegel was added to impart the requisite quantity of manganese, too much carbon would have been introduced, and alloys richer in manganese—known as ferro-manganese—have been sought and found.

By adding at the end of the process a known quantity of spiegel or ferro-manganese, containing a known quantity of carbon, steel of any required hardness could be obtained.

The year which saw the birth of the Bessemer process was doubly remarkable, for it was at that time that the regenerative system of heating was first introduced by Dr. Siemens. Nothing can be simpler than the principle involved in this method, yet it was destined to play a most important part in the progress of the arts. The idea was to store up the heat escaping in the waste gases from furnaces, and to employ it to raise the temperature of the gas and air previous to their combustion in the furnace. This was accomplished by causing the spent gases to pass through two chambers filled with loose brickwork. When these chambers have become heated to a high temperature, the waste gases are made to pass through two other similar chambers, and the air and gas necessary for combustion in the furnace are caused to pass through the highly heated regenerators. By causing the ingoing gases to pass alternately, at suitable intervals of time, through each pair of regenerators, a very high and, at the same time, uniform temperature can be obtained in the furnace, without any greater consumption of fuel than in the older methods. The success of this process depended entirely on the fuel being first converted into a combustible gas. This was done in a chamber to which only sufficient air is admitted to convert the carbon into carbonic oxide, which is then conducted by tubes to one of the regenerators to be heated, and thence to the furnace, where, coming in contact with air which has

been passed through the other regenerator, it burns, giving out intense heat.

There are two methods now in use for the production of steel in the reverberatory furnace, or open-hearth, as it is called. In France, pig-iron and scrap-steel are fused together; in England, pig-iron is decarburized by means of iron-ore, some scrap, however, being generally added for the sake of utilizing it. As in the Bessemer process, the necessary amount of carbon is imparted to the metal by the means of spiegeleisen or ferro-manganese. This process has been largely employed for the production of ship and boiler plates. It has the great advantage that the metal can be kept fluid on the hearth, and its composition adjusted until it is exactly that required.

In 1876 a patent was taken out by M. Pernot, in which it was proposed to produce steel on an open-hearth furnace with a revolving bed, inclined at an angle of 5° or 6° to the vertical. Pig-iron previously heated to redness is placed in the bed of the furnace and covered with scrap-steel. The bed of the furnace is then made to revolve slowly, the pig gradually melts, and the scrap is alternately exposed to the strong heat of the flame, and then dipped under the molten pig-iron. In this way the fusion is very rapid, comparatively, the whole mass becoming fluid in about two hours. The process is then completed in the ordinary way. M. Pernot informs me that he has just taken out a patent for an arrangement of his furnace by means of which he can employ gas under pressure, and that within the last few months he has obtained by this means results which have never been equaled before.

The Ponsard furnace aims at combining the advantages of the Bessemer and open-hearth processes. The furnace is so arranged that, by giving it a half-revolution on its oblique axis, the tuyères with which it is supplied may be brought either beneath or above the surface of the bath of metal. By these means the metal can be rapidly decarburized nearly entirely, as in the Bessemer converter, and then, by removing the tuyères from beneath the metal, the final adjustment of the carbon can be made as in the Siemens process. The rapid destruction of the tuyères which is effected is a formidable obstacle to the practical success of this process.

The one important drawback to the Bessemer process was that phosphorus was not in any degree eliminated by it. Notwithstanding this, enormous quantities of steel were made by it; and, within the last three years, means have been devised in the Thomas-Gilchrist, or "basic" process, by which this difficulty has been overcome. In the ordinary Bessemer converter the lining was formed of *ganister*, a siliceous material, the chemical effect of which was to prevent the elimination of phosphoric acid. Messrs. Thomas and Gilchrist sought a basic material which they could substitute for the ganister, and found a magnesian limestone which worked very satisfactorily. The

result of the application has been, that phosphorus has been converted from an enemy into a friend, and aids in producing and maintaining the temperature that is needed. Silicon is also useful as a combustible, and in preventing the metal from becoming honeycombed by escaping gases while solidifying. This it does by combining with oxygen and preventing the latter substance from combining with carbon and forming a gaseous product.

In consequence of the extremely high temperature which we can command, either in the Bessemer or open-hearth process, it is possible to obtain in a molten state a metal practically free from carbon, or containing carbon to any required amount. All of the products have been called steel, although they constitute in effect a new metal, having qualities considerably different from those of steel.

It thus has resulted that we speak of steel ships, steel boilers, and steel rails. The metal of which ship-plates are made contains about $\frac{13}{100}$ per cent. of carbon, that for boilers about $\frac{24}{100}$, while rails usually have about $\frac{4}{10}$. The first and the second could not be appreciably hardened, and the third is considerably below what would formerly have been considered steel.

At present there is but one sound reason why steel should not universally replace iron with advantage, and that is, that in some cases it is cheaper to employ iron. Statistics show us that the enormous quantities of steel now manufactured have but little, if at all, affected the production of wrought-iron. It is, however, I am convinced, but a question of time. When the day comes—and every day brings us nearer to it—when steel will be manufactured as cheaply as iron, then will wrought-iron be a thing of the past among the great civilized nations.

One word as regards the employment of steel made by these modern methods for cutlery. Cutlery-manufacturers would tell you that it is useless for the purpose; nevertheless, on the Continent, it is very largely used, and in this country to a considerable extent. I do not hesitate to assert that, with suitable ores and proper care in the manufacture, steel well suited for cutlery can be made both in the open-hearth and the converter. The essential in the ore is that it should not contain phosphorus; with but a trace of phosphorus present, a good cutting edge could never be obtained.

If we glance back for a moment to review our history, we shall see that the open-hearth processes embody the same principle as the first process by which steel was produced, viz., the mutual action of carburized iron and oxide of iron on one another, and the Bessemer process is, after all, though a splendid offspring, only the natural descendant of the finery process, the origin of which, as we have seen, was due to modifications in the primitive blast-furnaces. There is perfect continuity throughout, and, after all, what more natural?

INTELLIGENCE OF ANTS.

By GEORGE J. ROMANES.

II.

I HAVE now presented some of the most curious and interesting facts concerning the intelligence of ants in general; I shall next proceed to state some of the more remarkable facts concerning the intelligence of certain species of ants in particular.

Leaf-cutting Ants of the Amazon.—The mode of working practiced by these ants is thus described by Bates:

> They mount a tree in multitudes. . . . Each one places itself on the surface of a leaf, and cuts with its sharp, scissors-like jaws a nearly semicircular incision on the upper side; it then takes the edge between its jaws, and by a sharp jerk detaches the piece. Sometimes they let the leaf drop to the ground, where a little heap accumulates, until carried off by another relay of workers; but generally each marches off with the piece it has operated on, and, as all take the same road to the colony, the path they follow becomes in a short time smooth and bare, looking like the impression of a cart-wheel through the herbage.

Other observers have since said that this herbage is regularly felled by the ants in order to make a road. Each ant carries its semicircular piece of leaf upright over its head, so that the home-returning train is rendered very conspicuous. Keener observation shows that this home-returning, or load-carrying, train of workers keeps to one side of the road, while the outgoing, or empty-handed, train keeps to the other side; so that on every road there is a double train of ants going in opposite directions. When the leaves arrive at the nest they are received by a smaller kind of worker, whose duty it is to cut up the pieces into still smaller fragments, whereby the leaves seem to be better fitted for the purpose to which, as we shall presently see, they are put. These smaller workers never take any part in the out-door labor; but they occasionally leave the nest, apparently for the sole purpose of obtaining air and exercise, for when they leave the nest they merely run about doing nothing, and frequently, as in mere sport, mount some of the semicircular pieces of leaf which the carrier-ants are taking to the nest, and so get a ride home.

From his continued observation of these ants Bates concludes—and his opinion has been corroborated by that both of Belt and Müller—that the object of all this labor is a highly remarkable one. The leaves when gathered do not themselves appear to be of any service to the ants as food; but, when cut into small fragments and stored away in the nests, they become suited as a nidus for the growth of a minute kind of fungus on which the ants feed. We may therefore call these insects "gardening ants," inasmuch as all their labor is given to the rearing of nutritious vegetables on artificially prepared soil. They are

not particular as to the material which they collect and store up for soil, provided that it is a material on which the fungus will grow —orange-peel, certain flowers, etc., being equally acceptable to them. But they are very particular regarding the ventilation of their underground storehouses, on a suitable degree of which the successful growth of the fungus presumably depends. They therefore have numerous holes or ventilating shafts which lead up to the surface from the storehouses or underground gardens, and these they either open or close according to the horticultural requirements as regards temperature and moisture. If the leaves are either too damp or too dry, they will not grow the fungus, and therefore in gathering the leaves the ants are very particular that they should neither be the one nor the other. Thus Bates observed :

If a sudden shower should come on, the ants do not carry the wet pieces into the burrows, but throw them down near the entrances; should the weather clear up again, these pieces are picked up when nearly dried and taken inside; should the rain, however, continue, they get sodden down into the ground, and are left there. On the contrary, in dry and hot weather, when the leaves would get dried up before they could be conveyed to the nest, the ants, when in exposed situations, do not go out at all during the hot hours, but bring in their leafy burdens in the cool of the day and during the night.

Dr. Ellendorf made the experiment of interrupting the advance of a column of these ants, with the interesting result which he thus describes in a letter to Büchner :

Thick dry grass stood on either side of their narrow road, so that they could not pass through it with the load on their heads. I placed a dry branch, nearly a foot in diameter, obliquely across their path, and pressed it down so tightly on the ground that they could not pass underneath. The first comers crawled beneath the branch as far as they could, and then tried to climb over, but failed owing to the weight on their heads. Meanwhile the unloaded ants from the other side came on, and when these succeeded in climbing over the bough there was such a crush that the unladen ants had to clamber over the laden, and the result was a terrible muddle. I now walked along the train, and found that all the ants with their bannerets on their heads were standing still, thickly pressed together, awaiting the word of command from the front. When I turned back to the obstacle, I was astonished to see that the loads had been laid aside by more than a foot's length of the column, one imitating the other. And now work began on both sides of the branch, and in about half an hour a tunnel was made beneath it. Each ant then took up its burden again, and the march was resumed in the most perfect order.

The operations here described show clearly that these ants act upon the principle of the division of labor. In this connection I may also quote an observation of Belt, which shows this fact in perhaps even a stronger light. He says :

Between the old burrows and the new one was a steep slope. Instead of descending this with their burdens, they cast them down on the top of the slope,

whence they rolled down to the bottom, where another relay of laborers picked them up and carried them to the new burrow. It was amusing to watch the ants hurrying out with bundles of food, dropping them over the slope, and rushing back immediately for more.

Ants of this genus are very clever at making tunnels. The Rev. H. Clark says that in one case they have made a tunnel of enormous length under the river Parahylia, where this is as broad as the Thames at London—their object being to reach a storehouse which is on the opposite bank. This statement is not to be considered so incredible as it at first sight unquestionably appears, for Bates has seen the subterranean passages of these ants extending to a distance of seventy yards.

Harvesting Ants.—The harvesting ants belong almost exclusively to a single genus, which, however, comprises a number of species distributed in localized areas over all the four quarters of the globe. Their distinctive habits consist in gathering nutritious seeds of grasses during summer, and storing them in granaries for winter consumption. We owe our present knowledge concerning these insects mainly to Moggridge, who studied them in the south of Europe, Lincecum and McCook, who studied them in Texas; Colonel Sykes and Dr. Jerdon also made some observations upon them in India. They likewise occur in Palestine, where they were clearly known to Solomon and other writers of antiquity, whose claim to accurate observation in this matter has within the last few years been amply vindicated, after having been for many years discredited, on account chiefly of the adverse statements of Huber.

Moggridge found that from the nest in various directions there proceed outgoing trains, which may be thirty or more yards in length, and each consisting of a double row of ants moving in opposite directions. Like the leaf-cutting ants, those composing the outgoing train are empty-handed, while those composing the incoming train are laden. But here the burdens are grass-seeds. At their terminations in the foraging-ground, or ant-fields, the insects composing these columns disperse by hundreds among the seed-yielding grasses. They then ascend the stems of the grasses, and, seizing the seed or capsule in their jaws, fix their hind-legs firmly as a pivot, round which they turn and turn till the stalk is twisted off. The ant then descends the stem,

patiently backing and turning upward again as often as the clumsy and disproportionate burden becomes wedged between the thickly-set stalks, and joins the line of its companions to the nest. . . . Two ants sometimes combine their efforts, when one stations itself near the base of the peduncle, and gnaws it at the point of greatest tension, while the other hauls upon it and twists it. . . . I have occasionally seen ants, engaged in cutting the capsules of certain plants, drop them, and allow their companions below to carry them away; and this corresponds with the curious account given by Ælian of the manner in which the spikelets of corn are severed and thrown down "to the people below."

As further evidence that these insects well understand the advantages arising from the division of labor, I may quote one or two other observations. Thus Moggridge once saw a dead grasshopper carried into a nest of harvesting ants by the following means :

> It was too large to pass through the door, so they tried to dismember it. Failing in this, several ants drew the wings and legs as far back as possible, while others gnawed through the muscles where the strain was greatest. They succeeded at last in pulling it in.

Again, Lespis says of the harvesting ant that,

> if the road from the place where they are gathering their harvest to the nest is very long, they make regular depots for their provisions under large leaves, stones, or other suitable places, and let certain workers have the duty of carrying them from depot to depot.

No less, therefore, than the leaf-cutting ants already described, do these harvesting ants appreciate the benefits arising from the division of labor ; and, as we shall presently see, there is a kind of ant exhibiting widely different habits, which shows appreciation of this principle in an even higher degree.

When the grain is taken into their nest by the harvesters, it is stored in regular granaries, but not until it has been denuded of its "husks" or "chaff." The denuding process, which corresponds to thrashing, is carried on below-ground, and the chaff is brought up to the surface, where it is laid in heaps to be blown away by the wind. It is not yet understood why the seed, when thus stored in subterranean chambers just far enough below the surface to favor germination, does not germinate. Moggridge proved that the vitality of the seeds is not impaired, for he grew some plants from seeds taken from the granaries ; and he also found that the seeds would germinate even in the granaries, if the ants were prevented from obtaining access to them for two or three days. The non-germination of the seeds must, therefore, be due to some influence exerted by the ants. Moggridge thought this influence might be the exhalations from the ants, and so tried inclosing some seeds in a bottled test-tube, containing also earth and ants. The seeds, however, sprouted ; and even an atmosphere of formic-acid vapor was found not to prevent germination. Probably, therefore, the ants in their granaries do something to the seeds for the express purpose of preventing germination ; and, if so, it would be interesting to botanists to ascertain what this process can be.

But, be this as it may, there is no doubt that the ants are fully aware of the importance in this connection of keeping their garnered seeds as dry as possible ; for when the latter prove over-moist after collection, or have been subsequently wetted by soaking rains, the insects bring them up to the surface and spread them out to dry, to be again brought into the nest after a sufficient exposure.

Lastly, Moggridge observed that the process, whatever it is, where-

by the ants prevent germination, is not invariably successful, but that a small percentage of stored seeds sometimes do begin to germinate. When this was the case, he also observed the highly interesting fact that the ants then knew the most effective method of checking further germination, for he found that in these cases they gnawed off the tip of the sprouting radicle. This fact deserves to be considered as one of the most remarkable among the many remarkable facts of ant psychology.

Passing on now to the harvesting ants of the New World, the insects here remove all the herbage above their nest in the form of a perfect circle, or "disk," fifteen to twenty feet in diameter. Every grass or weed within the disk is carefully felled, and, as the nests are situated in thickly-grown localities, the effect of the bald or shaven disk is highly conspicuous and peculiar, exactly resembling in miniature the "clearings" which are made by settlers in the backwoods. The disk, however, is not merely cleared of herbage, but also carefully leveled—all inequalities of the surface being reduced by pellets of soil being built into the hollows to an extent sufficient to make a uniformly flat surface. In the center of the disk is the gateway of the nest. From the disk in various directions there radiate out-roads or avenues, which are cleared and smoothed like the disk. These roads course through the thick grass, branching and narrowing as they go, till they eventually taper away. They are usually four to seven inches wide at their origin, and may be from sixty to three hundred feet in length. Along these roads there is always passing during the daytime a constant double stream of ants, one being laden and the other not.

In their manner of gathering and garnering grain these harvesters resemble in general the harvesters of Europe; but it is alleged by Dr. Lincecum that in one respect their habits manifest an astonishing, and indeed wellnigh incredible, advance upon those of their European allies. For this observer, who, it must be remembered, was the first to call attention to these ants in the New World, and whose other observations, extending over a number of years, have since been fully confirmed—this observer states in the most positive terms that the ants actually sow the seeds of a certain plant called the ant-rice, for the purpose of subsequently reaping a harvest of grain; hence these ants have been called the "agricultural ants." Now, there is no doubt, from the subsequent observations of McCook and others, that the ant-disks do very frequently support this peculiar kind of grass, and that the ants are particularly fond of its seed. Nevertheless, McCook did not himself witness the process of sowing, although he is not disposed to doubt the statements of his predecessor upon the subject. These statements, as already observed, are most emphatic and precise—Lincecum saying, in italics, that he knows and is certain about the fact; but until corroborated it is safest to regard the fact as not yet fully established.

HONEY-MAKING ANTS.—These ants are found in Texas and New Mexico. Their remarkable habits have been observed by Captain Fleeson, who communicated his observations to Mr. Darwin.

The community consists of three distinct kinds of ants, which appear to belong to two distinct genera. These are :

I. Yellow workers ; nursers and feeders of II.

II. Yellow honey-makers ; sole function to secrete a kind of honey in their large globose abdomens, on which the other ants are supposed to feed. They never quit the nest, and are fed and tended by I.

III. Black workers ; guards and purveyors, which surround the nest as sentinels, and also forage for the food required for I. They are much larger and stronger than either I or II, and are provided with very formidable mandibles.

The nest is in the form of an absolutely perfect square, of which each side measures from four to five feet, and the surface of which is kept quite unbroken save at two points, at each of which there is a very minute hole or entrance. One of these minute holes occurs near the west side of the square, and the other near the southeast corner ; for it must be remarked that the square is always built with precise reference to the points of the compass, in such a way that one side faces due north, and consequently the others due south, east, and west. These boundaries are rendered very conspicuous by the guard of black workers or soldiers (III), which continuously parade round three of the sides in a close double line of defense, moving in opposite directions. This sentry-path occupies the north, east, and west boundaries, the south side of the square being left open ; but, if an enemy approaches on this or any other side, a number of the guards leave their stations and sally forth to face the foe, raising themselves on their hind-legs on meeting the enemy, and moving their large mandibles in defiance. After tearing the enemy to pieces the guards return to their places in the line of defense, their object in destroying any insect or other small intruders being defense of the encampment, and not the obtaining of food.

The southern side of the square encampment, or rather fortress, is left open as just described in order to admit of a free entry of supplies. While some of the black workers are on duty as gurad, another and larger division are engaged on duty as purveyors. These enter and leave the quadrangle by its southwest corner in a double line (one laden and the other not), which follows exactly the diagonal of the square to its central point, where all the booty, consisting of flowers and aromatic leaves, is deposited in a heap. Passing from this central heap to the entrance at the southeast corner of the quadrangle, and therefore occupying the other semi-diagonal of the square, there is another double line of workers constantly engaged in carrying the booty from the central deposit into the storehouses below-ground. These workers are exclusively composed of Class II, whose whole life

is therefore spent in running backward and forward upon this semi-diagonal of the square, carrying in food and feeding Class I. No black ant is ever seen on the eastern diagonal, and no yellow ant is ever seen on the western; but each keeps to his own separate station, and here works with a steadfastness and apparent adherence to discipline which are not less remarkable than those exhibited by the sentries. The western hole before mentioned seems to be intended only as a ventilating shaft; it is never used as a gateway.

Section of the nest reveals, besides passages and galleries, a small chamber, across which is spread, like a spider's web, a network of squares spun by the insects. In each of these squares, supported by the web, sits one of the honey-secreting ants (II). Here the honey-makers live in perpetual confinement, and receive a constant supply of flowers, pollen, etc., which is continually being brought them by I, and which, by a process of digestion and secretion, they convert into honey. It is particularly noteworthy that in this truly wonderful exhibition of social coöperation the black and yellow workers appear to belong to two distinct genera; for hitherto this is the only case known of two distinct species of animals coöperating for a common end.

Ecitons.—We have lastly to consider the most astonishing insects, if not the most astonishing animals, in the world. These are the so-called "foraging," or, as they might more appropriately be called, the military ants of the Amazon. They belong to several species of the same genus, and have been carefully watched by Bates, Belt, and other naturalists. The following facts must therefore be regarded as fully established:

Eciton legionis moves in enormous armies, and everything that these insects do is done with the most perfect instinct of military organization. The army marches in the form of a rather broad and regular column, hundreds of yards in length. The object of the march is to capture and plunder other insects, etc., for food, and, as the well-organized host advances, its devastating legions set all other terrestrial life at defiance. From the main column there are sent out smaller lateral columns, the composing individuals of which play the part of scouts, branching off in various directions, and searching about with the utmost activity for insects, grubs, etc., over every log and under every fallen leaf. If prey is found in sufficiently small quantities for them to manage alone, it is immediately seized and carried to the main column, but, if the amount is too large for the scouts themselves to deal with, messengers are sent back to the main column, whence there is immediately dispatched a detachment large enough to cope with the requirements. Insects or other prey which, when killed, are too large for single ants to carry, are torn in pieces, and the pieces conveyed back to the main army by different individuals. Many insects in trying to escape run up bushes and shrubs, where they are

pursued from branch to branch and twig to twig by their remorseless enemies, till, on arriving at some terminal ramification, they must either submit to immediate capture by their pursuers or drop down amid the murderous hosts beneath. As already stated, all the spoils which are taken by the scouts, or by the detachments sent out in answer to their demands for assistance, are immediately taken back to the main army or column. When they arrive there, they are conveyed to the rear of that column by two smaller columns of carriers, which are constantly running in two double rows (one of each being laden and the other not) on either side of the main column. On either side of the main column there are also constantly running up and down a few individuals of smaller size, lighter color, and having larger heads than the other ants. These appear to perform the duty of officers, for they never leave their stations, and, while actively running up and down the outsides of the column, they seem intent only on maintaining order in the march—stopping every now and then to touch some member of the rank and file with their antennæ, as if giving directions.

When the scouts discover a wasp's nest in a tree, a strong force is sent out from the main army, the nest is pulled to pieces, and all the larvæ in the nest are carried by the carrier-columns to the rear of the army, while the wasps fly around defenseless against the invading multitudes. Or, if the nest of any other species of ant is found, a similarly strong force is sent out, or even the whole army may be deflected toward it, when with the utmost energy the innumerable insects set to work to sink shafts and dig mines till the whole nest is rifled of its contents. In these mining operations the Ecitons work with an extraordinary display of organized coöperation ; for those low down in the shafts do not lose time by carrying up the earth which they excavate, but pass on the pellets to those above, and the ants on the surface, when they receive the pellets, carry them only just far enough to insure that they shall not roll back again into the shaft, and, after having deposited them at a safe distance, immediately hurry back for more.

The Ecitons have no fixed nest themselves, but live, as it were, on a perpetual campaign. At night, however, they call a halt and pitch a camp. For this purpose they usually select a piece of broken ground, in the interstices of which they temporarily store their plunder. In the morning the army is again on the march, and before an hour or two has passed not a single ant is to be seen where thousands and millions had previously covered the ground.

The habits of *E. humana* and *E. drepanophora* are in general similar to those of the species just described. The latter, however, march in a narrower column (only four to six deep), which is therefore proportionally longer—sometimes extending to over half a mile. Bates tried the effect of interfering with a column of this species by

abstracting an individual from it. "News of the disturbance was quickly communicated to a distance of several yards to the rear, and the column at that point commenced retreating." It was also this species that the same naturalist describes as enjoying periods of leisure and recreation when they call a halt in "the sunny nooks of the forest." On such occasions,

> the main column of the army and the branch columns were in their ordinary relative positions; but, instead of pressing forward eagerly and plundering right and left, they seemed to have been all smitten with a sudden fit of laziness. Some were walking slowly about, others were brushing their antennæ with their forefeet; but the drollest sight was their cleaning each other. . . . It is probable that these hours of relaxation and cleansing may be indispensable to the effective performance of their harder burdens; but, while looking at them, the conclusion that they were engaged merely in play was irresistible.

E. prædator differs from the others of its genus in not hunting in columns, but "in dense phalanxes consisting of myriads of individuals."

> Nothing (says Bates) in insect movements is more striking than the rapid march of these large and compact bodies. Wherever they pass, all the rest of the animal world is thrown into a state of alarm. They stream along the ground and climb to the summit of all the lower trees, searching every leaf to its apex, and, whenever they encounter a mass of decaying vegetable matter where booty is plentiful, they concentrate, like other Ecitons, all their forces upon it, the dense phalanx of shining and quickly-moving bodies, as it spreads over the surface, looking like a flood of dark-red liquid. They soon penetrate every part of the confused heap, and then, gathering together again in marching order, onward they move.

A phalanx occupies from four to six square yards of ground, and the ants composing it do not move "altogether in one straightforward direction, but in variously spreading contiguous columns, now separating a little from the general mass, now reuniting with it. The margins of the phalanx spread out at times like a cloud of skirmishers from the flanks of the main army."

Two species of Eciton are totally blind, and the habits of these differ from those above described in that they march exclusively under covered roads or tunnels. The van of the column is constantly engaged in rapidly constructing the tunnels through which the army or regiment advances as quickly as they are made. Under the protection of these covered ways the ants travel at a surprising rate, and, when they reach a rotten log or other promising hunting-ground, they pour into all the crevices, etc., in search of prey. Bates says:

> The blind Ecitons, working in numbers, build up simultaneously the sides of their convex arcades, and contrive, in a wonderful manner, to approximate them and fit in the key-stones without letting the loose, uncemented structure fall to pieces. There was a very clear division of labor between the two classes of neuters in these blind species. The large-headed class . . . act as soldiers,

defending the working community (like soldier termites) against all comers. Whenever I made a breach in one of their covered ways, all the ants underneath were set in commotion, but the worker-miners remained behind to repair the damage, while the large-heads issued forth in a most menacing manner.

These two blind species of Eciton are particularly interesting from the fact that in a part of the world so remote from them as Western Africa there is another genus of military ant, also blind, which in all its habits closely resembles the blind Ecitons of Brazil. For, like the latter, *Annornia arcens* march in long, close columns through tunnels, have no fixed nest, but make temporary halts in shaded places, and are no less organized, remorseless, and irresistible than their American congeners. In one curious particular, however, they differ: the relative position of the marchers and the carriers is reversed, for here the carrier-columns occupy the middle place, while the marching columns with their officers occupy the flanks. When overtaken by a sudden African rain-storm, these ants congregate in a close mass, with the younger ants in the center; they thus form a floating island.

It is remarkable that ants of different hemispheres should manifest so close a similarity with respect to all these wonderful habits. The Chasseur ants of Trinidad, and, according to Madame Merian, the ants of Visitation of Cayenne, also display habits of the same kind.

Special Instances of the Display of High Intelligence.—I shall conclude this brief *résumé* of the more important facts at present known concerning the psychology of ants with a few selected observations of the display of high intelligence. It is always difficult to draw the line between instinct and reason, between adjustive action due to hereditary or purposeless habit and adjustive action due to individual and purposive adaptation. But we may be least diffident in accepting as evidence of the latter cases where animals exhibit a power of adapting their actions to meet the requirements of novel circumstances—or circumstances which can not be supposed to have been of sufficiently frequent occurrence in the life-history of the species to have developed instincts of mechanical response in the individual. It is in view of this consideration that the following instances are selected.

Ebrard records in his "Études de Mœurs" an observation of his own on *F. fusca*. The ants were engaged in building walls, and when the work was nearly completed there still remained an interspace of twelve or fifteen millimetres to be covered in. For a moment the ants were thrown out, and

seemed inclined to leave their work, but soon turned instead to a grass-plant growing near, the long, narrow leaves of which ran close together. They chose the nearest, and weighted its distal end with damp earth, until its apex just bent down to the space to be covered. Unfortunately, the bend was too close to the extremity, and it threatened to break. To prevent this misfortune the ants gnawed at the base of the leaf until it bent along its whole length and covered the space required. But, as this did not seem to be quite enough, they heaped

damp earth between the base of the plant and that of the leaf, until the latter was sufficiently bent. After they had attained their object, they heaped on the buttressing-leaf the materials required for building the arched roof.

This observation naturally leads to two others by two different observers. Thus, Moggridge says: "I was able to watch the operation of removing roots which had pierced through their galleries, belonging to seedling plants growing on the surface, and which was performed by two ants, one pulling at the free end of the root, and the other gnawing at its fibers where the strain was greatest, until at length it gave way." Again, as previously quoted in another connection, he says that two ants sometimes combine their efforts, one stationing itself near the base of a footstalk and gnawing at the point of greatest tension, while the other hauls upon and twists it.

The other observer to whom I have referred is McCook, who says of the harvesting ants of America that he has seen "the workers, in several cases, leave the point at which they had begun a cutting, ascend the blade, and pass as far toward the point as possible. The blade was thus borne downward, and, as the ant swayed up and down, it really seemed that she was taking advantage of the leverage thus gained, and was bringing the augmented force to bear upon the fracture. In two or three cases there appeared to be a division of labor; that is to say, while the cutter at the roots kept on with his work, another ant climbed the grass-blade and applied the power at the opposite end of the lever. This position may have been quite accidental, but it certainly had the appearance of voluntary coöperation."

These observations serve to render less improbable the following quotation taken from Bingley's account of Captain Cook's expedition in New South Wales, and vouched for by Sir J. Banks. Green ants were seen forming their nests in trees by "bending down several of the leaves, each of which is as broad as a man's hand, and gluing the points of them together so as to form a purse. . . . We saw thousands uniting all their strength to hold them in this position, while other busy multitudes within were employed in applying the gluten that was to prevent their returning back."

Moggridge says that he has seen the harvesting ants of Europe clustering round the larva of a certain beetle, and directing it toward some small opening in the soil, "which it would quickly enlarge and disappear down"; and he believes that "these attentions were purely selfish," the ants availing "themselves of the tunnel thus made down into the soil."

McCook says of the harvesters of America that they dislike shade, so that if a tree grows up in their vicinity and casts a shadow over their nest they forthwith migrate. He gives in this connection a statement which I regard as bordering on the incredible, and therefore I desire it to be specially observed that it is not very evident from

McCook's account whether he himself witnessed the facts. The facts, however, which he narrates, are that a peach-tree having grown up so as to overshadow a nest of harvesting ants, the latter climbed the tree to strip off the leaves. "I am convinced," says McCook, "that the reason for this onslaught was the desire to be rid of the obnoxious shade." If this statement had been met with in any ordinary book on animal intelligence, of course I should not have quoted it; but as McCook went to Texas for the express purpose of studying these ants in a scientific manner, and as the numerous other observations which he made, both on these and on the mound-building species, entitle him to respect, I have not felt justified in suppressing this statement.

The observation made by Colonel Sykes on certain ants in India has gained a wide notoriety from its having been published by Spence in his popular work on instinct. Colonel Sykes was a good observer, so that his account ought not to be questioned. He says that in order to guard his provisions from the ants he put them on a table, the four legs of which he placed in as many basins filled with water. Some ants still succeeded in scrambling across the water, and so the legs of the table were likewise painted with turpentine. The ants then ran up a wall near which the table stood, and when about a foot above its level, they sprang from the wall to the table.

Somewhat analogous to this is the observation of Professor Leuckhart, who placed round the trunk of a tree, which had been visited by ants as a pasture for aphides, a broad cloth soaked in tobacco-water. When the ants, returning home down the trunk of the tree, arrived at the soaked cloth, they turned round, went up the tree again to some of the overhanging branches, and allowed themselves to drop clear of the obnoxious barrier. On the other hand, the ants which desired to mount the tree first examined the nature of the obstruction, then turned back and procured some pellets of earth, which they carried in their jaws and deposited, one after another, upon the cloth till a harmless road of earth was made across it.

This observation of Professor Leuckhart is in turn a corroboration of an almost identical one made more than a century ago by Cardinal Fleury, and communicated by him to Réaumur, who published it in his "Natural History of Insects" (1734). The Cardinal smeared the trunk of a tree with bird-lime, in order to prevent the ants from ascending it; but the insects overcame the obstacle by making a road of earth, small stones, etc., as in the case just mentioned. On another occasion the Cardinal saw a number of ants make a bridge across a vessel of water surrounding the bottom of an orange-tree tub. They did so by conveying a number of little pieces of *wood*, the choice of that material, instead of earth or stones, as in the previous case, apparently betokening no small knowledge of practical engineering—a knowledge which, as we shall presently see, is also shared by the Ecitons.

Büchner, in his recently published and translated work on "Mind in Animals," gives a singular observation analogous to the above, which was communicated to him by Herr G. Theuerkauf. A maple-tree standing in the grounds of Herr Vollbaum, of Elbing, swarmed with ants and aphides. In order to check the mischief, the proprietor smeared about a foot width of the ground around the tree with tar. The first ants that arrived stuck fast; but the next, seeing the predicament of their companions, turned back and fetched a number of aphides from the tree, which they stuck down on the tar one after another till they had made a bridge over which they could cross without danger.

It will be observed that all these cases, being so analogous although recorded independently by different observers, serve to corroborate one another. As such corroboration in matters of this kind is of value, I shall here add two or three cases which go to confirm the observation of Cardinal Fleury regarding the construction of a floating bridge. Dr. Ellendorf writes to Professor Büchner that he protected a cupboard of his provisions from the invasion of ants by standing the legs of the cupboard in saucers filled with water. He adds:

I myself did this, but I none the less found thousands of ants in the cupboard next morning. It was a puzzle to me how they crossed the water, but the puzzle was soon solved. For I found a straw in one of the saucers. . . . This they had used as a bridge. . . . I pushed the straw about an inch from the cupboard-leg, when a terrible confusion arose. In a moment the leg immediately over the water was covered with hundreds of ants feeling for the bridge in every direction with their antennæ, running back again and coming in ever larger swarms, as though they had communicated to their companions within the cupboard the fearful misfortune that had taken place. Meanwhile the new-comers continued to run along the straw, and, not finding the leg of the cupboard, the greatest perplexity arose. They hurried along the edge of the saucer, and soon found where the fault lay. With united forces they pulled and pushed at the straw, until it again came into contact with the wood, and the communication was again restored.

The military ants, both in America and Africa, exhibit still more extraordinary resources in the way of bridge-making. Thus Belt says of the Ecitons:

I once saw a wide column trying to pass along a crumbling, nearly perpendicular, slope. They would have got very slowly over it, and many of them would have fallen; but a number having secured their hold, and reaching to each other, remained stationary, and over them the main column passed. Another time they were crossing a water-course along a small branch, not thicker than a goose-quill. They widened this natural bridge to three times its width by a number of ants clinging to it and to each other on each side, over which the column passed three or four deep; whereas, excepting for this expedient, they would have had to pass over in single file, and treble the time would have been consumed.

It is remarkable that the military or driving ants of Africa exhibit precisely similar devices for the bridging of streams as the Ecitons of America, namely, by forming a chain of individuals over which the others pass. By means of similar chains they also let themselves down from trees.

But of the Ecitons another and more recent observer gives an account of a yet more remarkable device, although no doubt a development of the one just described. This observer is Herr H. Kreplin, who lived for nearly twenty years in South America as an engineer, and often had the opportunity of watching the Ecitons. He writes to Büchner under date 1876 as follows:

If the water-course be narrow, the thick-heads (officers) soon find trees, the branches of which meet on the bank of either side, and after a short halt the columns set themselves in motion over these bridges, rearranging themselves in a narrow train with marvelous quickness on reaching the farther side. But, if no natural bridge be available for the passage, they travel along the bank of the river until they arrive at a flat, sandy shore. Each ant now seizes a bit of dry wood, pulls it into the water and mounts thereon. The hinder rows push the front ones ever farther out, holding on to the wood with their feet and to their comrades with their jaws. In a short time the water is covered with ants, and when the raft has grown too large to be held together by the small creatures' strength, a part breaks off and begins the journey across, while the ants left on the bank busily pull their bits of wood into the water and work at enlarging the ferry-boat until it again breaks. This is repeated as long as an ant remains on shore.

I shall now bring these numerous instances to a close with a quotation from Belt, which reveals in a most unequivocal manner astonishing powers of observation and reason in the leaf-cutting ants of South America, the general habits of which we have already considered:

A nest was made near one of our tramways, and to get to the trees the ants had to cross the rails, over which the wagons were continually passing and repassing. Every time they came along a number of ants were crushed to death. They persevered in crossing for some time, but at last set to work and tunneled underneath each rail. One day, when the wagons were not running, I stopped up the tunnels with stones; but although great numbers carrying leaves were thus cut off from the nest, they would not cross the rails, but set to work making fresh tunnels beneath them.

Such, then, are some of the more well-established facts regarding the intelligence of ants, and taken altogether they certainly seem to justify the remark of the most illustrious of naturalists, "The brain of an ant is one of the most marvelous atoms of matter in the world, perhaps more so than the brain of a man."—*Nineteenth Century.*

FOREST-CULTURE IN ALPINE RAVINES.*

By M. J. CLEVE.

WHATEVER differences of opinion may exist respecting the meteorological influence of forests, it is generally agreed that in mountainous countries they play an important part in regulating water-courses and in preserving the soil on the slopes of the hills. This function, which has been observed for a long time, was presented in a clear light by M. Surrell, engineer of bridges and highways, whose fine work on the torrents of the high Alps ("Torrens des Hautes-Alps"), published in 1841, has been the point of departure for all studies and all legal projects respecting rewooding. While the author had in view only the restoration of the French Alps, his conclusions are applicable, although in different degrees, to all mountainous countries; but the phenomena which he considers are manifested with the most intensity in the Alps, and the renewal of the woods there is imposed as a real measure of public policy.

In respect to vegetation, nature has divided the Alpestrian mountains into three zones: creating on the summits, around the rocks and glaciers, pasture-lands; on the middle slopes, forests; in the lower valleys, lands suited to occupation by agriculture and by villages. Unfortunately, this natural division has been too often disturbed; the inhabitants, leaving the valleys, have established themselves in the higher regions, have cut down the forests around their houses, and devoted to cultivation lands which, disintegrated by the plow, are incessantly cut up into ravines by every rain; or the zone of pasture-lands has encroached on that of the forests, and has been increased by the daily devastations of the shepherds. Extending its borders every year lower down the mountain, it has finished by taking possession of the slopes and despoiling them of their wood. Gradually the grass itself, no longer protected by the cover of large trees and continually fed upon by hungry flocks, has disappeared, leaving behind it only the denuded flank of the mountain, an easy prey of which the torrents have not been slow to take possession.

The mountain-torrent is not an ordinary brook, but is a stream with characters of its own and peculiar ways. Originating in a narrow basin, the bed of which is very steep, it is subject to sudden variations;

* [Some instructive reports have recently been published in France concerning the progress that has been made in rewooding the slopes of the Alps, which, having been stripped of trees, are most exposed to the ravages of torrents. While the Alps present features which have no counterpart in the settled regions in the United States, the problems which had to be solved in reclothing the lower parts of the mountains with wood and staying the processes of devastation involve principles which may be applied as well in our own hilly and mountainous districts.—Editor.]

often wholly dry, it becomes a flood after a storm, and overcomes all the obstacles that oppose its course. There are clear torrents and muddy torrents. The former, which are the torrents of eruptive regions, carry but little matter with them, and are characterized by sudden freshets, which are due to the fact that the waters running over impermeable rocks, are precipitated immediately into the ravines and collect in considerable masses. The torrents of the second class have formed themselves beds in the loose soil, are continually washing away the bases of their banks, provoking slides, carrying with them solid matters derived from the degradation of the hills, and discharging them in the lower valleys and covering the fields with a thick mud. The bed of the torrent is washed out more and more, and the banks increase at the same time; new ravines are formed, and branches of them, thus eating away the spur of the mountain, which is gradually destroyed, or which, undermined at the base, occasionally slides bodily into the valley, which it closes up.

Attention has long been given to devising means to limit the ravages of these torrents, which ruin the land, threaten estates, destroy roads, and sometimes even compromise the existence of villages. Walls have been built along the banks to protect them, or across the streams to allay the force of the waters. The most efficacious means, however, as yet discovered, has been to maintain the woods on the slopes of the mountain. The effect of cutting away the trees in promoting the formation of torrents has not been doubted by the inhabitants of mountainous regions, and is clearly set forth by M. Surrell, who says: "When we examine the tracts in the midst of which torrents of recent origin have been formed, we perceive that they have in all cases been despoiled of their trees and bushes. If, on the other hand, we examine hills whose sides have been recently stripped of wood, we observe that they are cut up by numerous torrents, which have evidently been formed very lately. Here is a remarkable double fact: wherever there are recent torrents there are no longer forests, and wherever the ground is cleared these torrents are formed; and the same eyes that see the woods fall on the declivity of a mountain, may see appear there immediately a multitude of torrents."

The disastrous consequences of removing the woods from the Alps began to attract attention in the last century, and have since been discussed in many publications and official reports. In 1853 the prefect of the department of the Lower Alps said in a report to the Minister: "If prompt and energetic measures are not taken, it will be almost possible to designate the precise moment when the French Alps will become a desert. The period from 1851 to 1853 will produce a new diminution in the number of the population. In 1862 the Minister will remark a continuous and progressive reduction in the number of hectares devoted to agriculture; each year will aggravate the evil, and in a half-century France will count more ruins and one depart-

ment less." The departments of the Upper and Lower Alps actually lost thirty thousand inhabitants, or one ninth of their population, between 1851 and 1876. A law for recovering the mountains with wood, which had been prepared by M. Forçade de Rouguet, director-general of the administration of the forests, was adopted by the legislative bodies in 1860, and was put in operation shortly afterward.

In some cases, the work of planting woods is left optional, but is encouraged by the offer of rewards to the communes or individuals who undertake it. In other cases, where the public interest is at stake, the state determines the area of land to be planted, and allows the proprietors to perform the work if they will; if they refuse to do so, it attends to the matter itself, taking care that its proceedings shall be as inoffensive to the people as they can be made, and be at the same time effective.

The first question that is presented in dealing with a hill that has been cut up with ravines is to determine the perimeter of the lands to be restored. The area should not be limited to the banks of the torrent and its branches, for these banks, being continually undermined and always changing, would continue, by giving way, to enlarge the basin if they were not themselves fixed by vegetation. The justice of the rules which M. Surrell laid down on this point in 1841 has been confirmed by experience. We should begin, he said, to trace along either bank of the torrent a continuous line which shall pursue all the inflections of its course, from its remote origin till it issues from the gorge upon the lower valley. The tract included between each of these lines and the crest of the banks would form what I would call a zone of defense. The zones of the two banks would meet at the upper end, following the contour of the basin, and would thus surround the torrent, like a belt, in its whole extent. Their width, which should vary with the degree of the slope and the consistency of the soil, may be as little as fifty yards at the lower end, but should increase rapidly as the zone rises up the mountain, and should end by including spaces of five or six hundred yards. This delineation is applicable not only to the principal branch of the torrent, but also to the secondary torrents that empty into it, and to the smaller ravines departing from each of these torrents, and thus, pursuing one branch after another, should not stop till it reaches the source of the most remote rill. As these zones of defense go on enlarging up the mountain, they will join, and even merge into each other toward the summit, so as to form a continuous band around the upper part, leaving no void in it.

The perimeter of the land to be rewooded having been determined, the next step is to prohibit pasturage, in order to prevent further disintegration of the soil by the feet of the sheep, and allow the grass to recover. The ultimate result is assisted by cutting the bushes down to the stump, and planting willow-cuttings in horizontal rows about two yards apart, to hold the earth on the almost vertical slopes, and

then sowing the seeds of grasses in the intervals. Concurrently with these preliminary operations, the only object of which is to prepare the soil for the reception of the forest-growth to be planted later, the torrent itself is attacked with works intended to impede its course, hold back the drift-matter, and prevent further undermining of the banks. For this purpose wattles and bars are inserted along the stream and its smallest ramifications, beginning generally at the upper parts, where the water, not having acquired its full force, can be more easily stopped, and the suspended matter may be more easily retained. Green branches of willow and hazel are woven around stakes in the ravine, take root in the soil, and become a living obstacle which perpetuates itself. If the wattles are close enough together, they will transform the ravine into a kind of staircase, by the agency of which the violence of the water is allayed at each step, its force is lessened so that it does not wear upon the soil, and it is made to run almost clear.

More energetic measures are required lower down, where the torrent exercises a more destructive action. Here dams of masonry are inserted in the banks, provided with an arched channel in the lower part to permit the outflow of water at moderate stages of the stream; they serve to hold back the stones that are worked out from the mountain, to promote the growth of alluvions, to break the fall of the torrent and diminish its violence by enlarging its bed. Some of these dams are real works of constructive art, and have cost as much as eight or ten thousand dollars.

The real replanting of the woods is done after the ground has become settled and the torrent has been subdued. Nurseries of young trees suitable for the purpose are previously established near the locality of the works, which are drawn upon as the plants are needed. The species vary according to the nature of the situation and the soil. Generally pines and firs of different kinds are best adapted to the higher situations, deciduous trees to the lower ones. Use has also been made of several species of shrubs and bushes, which with their branching roots are wonderfully fitted to fix the earth, and by reason of their rapid growth quickly furnish a shade to the bare surface. The planting is begun at the top of the elevation and is conducted downward, in such a manner as to leave no places vacant. The young trees, protected against the sun by the grasses which were previously sown and by the willow-cuttings which have already taken root, soon begin to grow with vigor. An effort was made, in accordance with the law of 1864, to substitute regrassing for replanting with wood in the interior of the perimeters; but it did not answer the purpose of consolidating the soil, and was abandoned. Sometimes the communes have shown themselves hostile to the execution of these works on account of the interdiction of pasturage. Such was the case in the communes of Orres and Saint-Sauveur, whose inhabitants drove away the workmen in 1864. The work was resumed three

years afterward, after it had been completed in an adjoining commune, and the people were conciliated by being employed in it. The upper valley of the torrent of Vachères, which was formerly considered one of the largest and most violent torrents of the Alps, once all cut up into ravines, is now covered with vegetation, and the torrent itself is described as extinct; once the terror of the country, it has been changed, at an expense of twenty-four thousand dollars, into an inoffensive river.

Like results have been obtained wherever works of the kind have been executed. M. Gentil, an engineer, reports of one district: "The aspect of the mountain has been changed all at once. The soil has acquired such stability that the violent storms of 1868, which caused great disasters in the high Alps, fell harmlessly on the regenerated perimeters. The mountain has at the same time become productive; where a few sheep could hardly live by destroying everything, may now be seen abundance of grass fit to mow. This method of improvement is remarkable for giving the people what they need most, and for giving it to them with only a brief delay. The pastoral inhabitants find food for their flocks in the grasses and hay of the planted areas and in the foliage of the trees; and the acacias that have been caused to grow there will soon furnish them the wood they will need in their vineyards. The torrential character of the stream has disappeared; the water is less turbid, even in time of rain, and is better adapted to purposes of irrigation. It is no longer loaded with solid matter when it reaches the lower valleys, and naturally keeps its bed. . . . Diversions from the regular course are less liable to occur and less dangerous, and the people on its banks can protect themselves with slight expense." M. Gentil relates several examples of torrents formerly very dangerous which have been fully and permanently subdued by means of such works as have been here described, giving protection to highways that were often interrupted before, and security to valleys that were often in danger, and adds: "Immense benefits have accrued to the lands situated in the lower valleys near the discharging basins of the streams. Not only are the inhabitants delivered from the expense of keeping up costly and precarious dikes; their property, also, being no longer in danger of being suddenly buried under a flood of gravel, has acquired a fixed value. They are able to till their land hopefully, and with the assurance that they will enjoy the crop. This certainty is a blessing of enormous value. The proprietor, able to rely upon the future, will no longer think of leaving the country."

So far as the work of restoration has been executed, its success—in respect to the processes employed and the results obtained—has been complete. The chief question concerning it which remains is as to the extent to which it shall be systematically carried out.—*Revue des Deux Mondes.*

CATTLE-RAISING IN SOUTH AMERICA.

By M. COUTY,

PROFESSOR IN THE POLYTECHNIC SCHOOL OF RIO JANEIRO.*

CATTLE-RAISING is far from having attained a sufficient importance in Brazil. Immense provinces, like those of Goyaz and Matto-Grosso, vast regions from the Amazon to the Parana, where cattle could be raised easily and without care, remain unutilized for want of a market and of convenient means of transport and conservation. There exist, however, some important stock-raising tracts and cattle-exchanges.

I have visited the provinces of Parana and Rio Grande and the state of Montevideo, and what I have to say relates only to those regions. Being neither an agriculturist nor a zoötechnist, I have had to limit myself to incomplete observations, and have endeavored to see how those cattle which are described as half wild, and are without any apparent direct relations with man, have been able to adapt themselves in a definite manner to the different conditions of their life.

Nothing can be more interesting than to study those conditions in which cattle live and are propagated without stables and without an assured supply of food; nothing more instructive than to observe how the time of heat, and consequently of births, the proportion of the young, and even their survival, are differently regulated according to the character of the country, in consequence of different physical conditions. Nothing, moreover, can be more curious than to study the habits of these supposed wild cattle, to see them living in isolated societies, possessing real notions of what is belonging to them, and each member of the community keeping his place. These facts are of further importance, because they have served for the empirical basis of the actual conditions, as they will have to serve as the basis of an improved system of breeding. In all these countries the life of the cattle is wholly free. The stock-raiser, or *estancier*, is the owner of a very extensive tract of pasture-land, and he leaves the animals to live upon it, feed themselves, and multiply at their will. The stock, even in the wildest and least populous regions, form small herds of from one hundred to one hundred and fifty head, which are made up of steers, cows, calves, and bulls; but are always composed of the same individuals, and always inhabit the same very limited region of the *campo*, and the animals pass their lives within this region without being confined by any inclosure. The distinctive character of the

* M. Couty was recently charged by the Minister of Agriculture of Brazil to visit the southern part of the empire and the neighboring states for the information of the department. The paper of which the most essential parts are here given embodies the results of his inquiries.

groups is especially curious in the more populous regions, as the southern part of Rio Grande or Montevideo, where herds may be seen almost in contact without mixing, coming together and making themselves up generally without trouble; and they live thus side by side for years without becoming acquainted with each other. Each herd is so coherent that, when one of its members takes fright and runs away, all will follow it. In consequence of this habit, it is very difficult, when cattle are sold, to separate them from the herds and to get them along for the first few leagues. If they are not watched, they will escape, pass by thousands of other animals without noticing them, and join their companions again. They cease, however, to seek to go back after they have been driven to a considerable distance.

The cattle in these herds also propagate in freedom. Traveling in Parana at a time when the pasturage was excellent and the cattle were in good condition, in January, I saw numerous vigorous bulls living as peacefully as could be with the cows.

The care given by man to the cattle enjoying this freedom of life and procreation, although very restricted, is greater than has been represented. A *rodeo*, or gathering of the different herds at a single point, is held at determined periods, both in Parana and the Oriental Republic. The assemblage may take place near the buildings in an *estancia* of moderate size, often in an inclosed space of suitable capacity called the *mangueira*. In extensive estancias having numerous herds, as it would be almost impossible to collect ten or twenty thousand head at a single point, several rodeos are made in different parts of the campo, always at the same points. In other estancias, notably in Parana, one or two grand rodeos a year are made at the mangueira, and several smaller rodeos at less intervals. The task of driving the cattle up to the rodeo is not a hard one. The beasts stagger along, and go in a mass toward the habitual point of gathering, generally with the bulls at their head The assemblies are kept up for a greater or less length of time, and the peons circulate around the herd, shouting so as to accustom the animals to the presence of man, and to the custom of coming up. The rodeo gives an opportunity to judge of the condition of the flocks, when and what proportion of them may be ready for sale; to practice treatment or different operations; to give the stock salt in Parana, and medical attention in other regions; to mark them and castrate them. Each estancia has its particular mark—often several marks; for in many estancias all the children have their share of the cattle, and, as the slaves also are sometimes allowed to own stock, confusion would result if means were not taken to prevent it.

The intervention of man is also illustrated in the efforts at cross-breeding. I was surprised at the manner in which this is attempted in South America. Everybody wants to acclimatize the races of Europe, and to improve the meat and fattening qualities of the stock; and, to this end, thorough-bred bulls (Herefords, and especially Dur-

hams) have been imported at great expense. An owner desiring to improve the stock of an estancia containing twenty thousand head, will procure three or four Durham bulls, and then will be astonished that the desired effect is not more rapidly produced. He ought not to forget that cross-breeding can not succeed between races so different except upon the condition that the new blood is continually renewed. To transplant the most artificial breed, and the one most difficult to maintain, into a dried-up southern campo, is one of the aberrations which a complete ignorance of European breeding and the taste for imitation alone can explain. It is also surprising that hardly anything has been done, in a region where everything is so favorable, to improve from themselves the races which have already become adapted to the medium and been molded by it. Cross-breeding, although it is highly esteemed, has been tried only in a limited number of estancias, and the selection of the best native stock has not been seriously attempted on any of the estates that I have observed. Although backward in respect to selection, the intervention of man has brought about an improvement in a no less important point of view, in the shape of measures to secure a more regular supply of food. In Parana the grass of the campos is burned at the dry season, in September and October of each year, certain parts, bounded by streams or ditches, being reserved to be burned later, so as to secure a succession of pasturage. In this state, as farther south, another equally simple means of preserving the natural food has been much employed. The most moist, least exposed, or best parts of the campo are inclosed, forming *hivernadas*, if the tract is large, *potreiros*, if it is small, for the cattle which are to be fattened. No inclosures large enough for all the stock have been made yet. These means, however, do not create new food, but only utilize that which already exists, and are of no use when a reserve of food is most necessary—that is, after frosty weather, and at the end of long droughts.

Two other measures might be adopted to assure a regular supply of pasturage, but they have hardly been tried. The easier course would be to install regular irrigation. In Parana the country is hilly, and the water-courses are everywhere maintained through the hot seasons. Farther south, it might be possible to irrigate large tracts through the whole year. Estanciers who, like M. Carlos Reyles at Durasno, have instituted irrigation on a considerable scale, have realized increased profits from it. Nevertheless, it is easy to count the breeders who have tried irrigation. There is probably not one in Parana, where, if you suggest it, the breeder will answer that an excess of water will promote the growth of worthless plants. The condition of the cattle might be improved, and the return from them increased, by dividing the enormous droves, which may now count from four to thirty thousand head, into herds of from five hundred to a thousand head. Now, all the half-wild cattle—*bravos*, as they

call them—have an extreme fear of man; it is dangerous to approach them on foot. They are prone to abandon their calves, and give them insufficient food. On the other hand, the cattle in small herds, or *manses*, breed much better and more rapidly. In Parana, many estanciers have, besides the droves of *bravo* cattle, four or five hundred head of *manse* cattle, which are kept to be milked; the latter live in the same campo, equally free with the others, but nearer the buildings. Nothing can be more surprising than to observe the differences in the aspect and in the productiveness of the two classes, whose conditions differ only in their having a greater or less familiarity with man. Ultimately, when these regions shall have become more populous and divided into smaller estates, the *manse* cattle will predominate, and systematic breeding will take the place of the present free-range practice; but at present the fact must be recognized that the rearing on a grand scale of the half-wild stock is the only system that gives returns; this method is, however, I am assured, competent to produce a stock equal to some of the better-managed races of Europe. The natural physical conditions under the operation of which the production of cattle must be maintained and promoted in these regions, are liable to considerable variation, even within the limited territory which I have visited.

The operation of the differences as a whole is revealed in the variations in the annual sales in the several regions. In Parana the proportion of animals sold is excessively small, being only about one twentieth of the total number of cattle for each year, but it is regular; while it rises to from one tenth to one eighth in Rio Grande and Montevideo, and to a still higher figure farther south, but is very irregular, falling sometimes below that which rules in Parana. That even the larger proportion of sales is smaller than that which obtains in Europe, is easily explained by reference to the differences in the prevailing conditions; but why such differences should exist between two regions of South America where the same system of raising is practiced, is an interesting subject of inquiry. The animals grow quite slowly in Parana, and are hardly ready to send to market till they are four or six years old, and are well developed and shapely; in the southern districts they are as a whole smaller, but are more rapidly developed, and are sold when only three or four years, or even less than three years, old. Then, while in Europe, nearly every cow is expected to give a calf each year, in Rio Grande and Montevideo the number of calves is only eighty per cent., in Parana only fifty per cent. that of the cow. In Parana the calves are nearly always born at or near the same time of the year, between September and November, while in Rio Grande and Montevideo the time of calving varies with different years, and even in the same year on different estates, and the proportion of calves is likewise irregular. The estancias of Montevideo are liable to visitations by epidemics which often carry off

thousands of head of stock; those of Parana are liable to a single affliction which is troublesome, the grub, from which the more southern districts are comparatively free. In Parana, the animal having passed his first year, continues to grow regularly and safely; in the southern districts he is exposed to many dangerous affections. The Parana animal has symmetrical proportions, a good size, well-developed bones, a thick hide well provided with hair, horns firmly planted and curved; the color only is variable. The southern stock, although faster growing, are irregular in their proportions, smaller than those of Parana, and do not give as much clear beef.

These diversities are attributable to differences in the media in which the cattle live. The seasons at Parana are regular. One, from December till the end of March, is marked by heavy rains coinciding with great heat; the other, including the rest of the months, is without rains or storms, but has abundant dews—a season of seven months of drought. The seasons are irregular in the southern regions. The winters are colder than in Parana, and are attended with heavy frosts. Long storms are not infrequent, and are often destructive to stock. The rains are not to be depended upon, but the heaviest of them fall in the winter; and the dry seasons come at irregular intervals. Calves are regularly born in the same months in Parana, because the animals, after having been exhausted by the long drought, have recovered their strength in the rich pasturage of December and January, and are in the best condition for heat in the following months. The seasons of calving are irregular in the southern districts because the times when the rains fall and the pastures are good, on which the procreative ability of the animals depends, are irregular.

These facts are very remarkable, for they show that reproduction is not regulated directly by the climate or the season, but indirectly, through the condition of the pasturage. The further development of the young animal is also affected by the same condition. The Parana calf, born during the dry season, is badly nourished at first, but finding the pastures rich just when it has grown large enough to graze, and beginning at the same time to receive an abundance of milk from its mother, it takes on a rapid development, and soon becomes strong enough to endure the coming dry season. This season carries off all the weaker animals, especially those that are calved at a later than the normal time, and has in this manner contributed to the perfection and perpetuation of the characteristics of the breed.

The case is quite different in the south, where the increase and growth of the animals are as irregular as the seasons; great losses occur under exceptional conditions of weather; and herds are sometimes reduced one half in consequence of long droughts.

The capacity of the stock in Parana to endure the long annual droughts is doubtless increased by certain accessory features in the nature of the soil and in the wooded growth. The soil is clayey, and

not easily permeable by water. It accordingly retains the moisture, and is fitted to form the bed of streams which never become dry. The pasture-lands are diversified with woods which are wanting in the more southern districts, and these give the animals shelter when they need it, and furnish them with a certain amount of browse, though it be of inferior quality, when the grass fails. There are other differences, mostly relating to matters of detail, which have not yet been sufficiently studied to make their bearing well understood, but all of which appear to illustrate the fact that the life of the stock, its increase, and its development, depend on the complex relations of certain physical conditions, such as the temperature, the time and amount of rains, the character of the soil, the presence or absence of wood, all of which act through their influence upon the supply of pasturage and food. A careful study of the media in which the cattle live and by which their development is governed and their habits are regulated, the points of difference between them, and the varying effects they produce in the animals exposed to their influence, might result in adding another page to what has been written on progressive evolution and adaptation.—*Translated from Revue Scientifique.*

BIOGRAPHICAL NOTICE OF PROF. C. A. YOUNG.

AMONG the original cultivators of astronomy who give honor alike to the American name and to the science of the age, a distinguished place must be assigned to CHARLES AUGUSTUS YOUNG, the present Professor of Astronomical Science in the College of New Jersey, at Princeton. He was born at Hanover, New Hampshire, December 15, 1834, and may be said to have had astronomy in his blood, being descended from professors of that science on both sides for two generations. His father, Professor Ira Young, occupied the chair of Natural Philosphy and Astronomy in Dartmouth College; and his mother's father, Professor Ebenezer Adams, held the same position in that institution still earlier. He fitted for college at home, and graduated at Dartmouth at the head of his class in 1853.

After graduation he was for three years a teacher of classics in Phillips Academy, Andover, Massachusetts. In 1856 he accepted the appointment of Professor of Mathematics, Natural Philosophy, and Astronomy in Western Reserve College at Hudson, Ohio, and the next year he married Miss Augusta J. Mixer, of Concord. He remained at Hudson till 1865, and during the time of his connection with the Western Reserve College his vacations were spent in astronomical work for the survey of the Western and Northwestern lakes. At the same time he deviated from his peaceful college occupations into the profession of war. He became a military captain, and commanded a company of

one-hundred-days men, mostly composed of the students of the college, who had volunteered at the call of Governor Tod, of Ohio, in 1862. The company was ordered to Vicksburg as escorts to a cartel of exchanged prisoners, and Professor Young's health received injuries during the expedition from which he has never entirely recovered.

He returned to his native town of Hanover in 1865, to take the professorship of Natural Philosophy and Astronomy in Dartmouth College, the same which had been held by his grandfather, and his father, who died in 1858. He was connected with this institution until 1877. During this time he was actively engaged on several astronomical expeditions. He was a member of the party which, under the charge of Professor J. H. C. Coffin, observed the eclipse of August 7, 1869, at Burlington, Iowa. Professor Young had devoted himself with great assiduity to spectroscopic investigations, and he had charge of the spectroscopic observations of the party. It was there that he discovered the green line of the corona spectrum, and identified it with the "1.474" line of the solar spectrum. It may be observed that Professor Harkness also discovered the same line on the same occasion, at Des Moines, though, on account of the inferior power of his instrument, he did not identify it correctly. In the winter of 1870–'71 Professor Young was a member of the Coast Survey party which, under the charge of Professor Winlock, observed the eclipse of December 22d at Jerez in Spain. It was on this occasion that Professor Young made his interesting discovery of what is called the "reversing layer" of the solar atmosphere, giving a bright-line spectrum correlative to that of the ordinary dark-line spectrum of sunlight. This remarkable effect is thus described by Professor Young, in his new work on the sun: "At a total eclipse of the sun, at the moment when the advancing moon has just covered the sun's disk, the solar atmosphere of course projects somewhat at the point where the last ray of sunlight has disappeared. If the spectroscope be then adjusted with its slit tangent to the sun's image at the point of contact, a most beautiful phenomenon is seen. As the moon advances, making narrower and narrower the remaining sickle of the solar disk, the dark lines of the spectrum for the most part remain sensibly unchanged, though becoming somewhat more intense. A few, however, begin to fade out, and some even turn palely bright a minute or two before the totality begins. But the moment the sun is hidden, through the whole length of the spectrum, in the red, the green, the violet, the bright lines flash out by hundreds and thousands, almost startlingly; as suddenly as stars from a bursting rocket-head, and as evanescent, for the whole thing is over within two or three seconds. The layer seems to be only something under a thousand miles in thickness, and the moon's motion covers it very quickly."

In August, 1872, Professor Young was stationed at Sherman, Wyoming Territory, the summit of the Pacific Railroad, to make solar

spectroscopic observations in connection with the Coast Survey party. While there he made out a catalogue of 273 lines reversed in the chromosphere spectrum, and 104 lines modified in the spectrum of sun-spots. In 1874 he went to Peking, China, as assistant astronomer in the party of Professor Watson, which observed the transit of Venus.

While at Hanover Professor Young devoted most of the time which could be spared from college duties to astronomical and spectroscopic observations, and he devised a form of automatic spectroscope which has been very generally adopted, and a description of which was formerly given in "The Popular Science Monthly." He also made a great number of new and instructive observations on the phenomena of solar prominences, and observed some remarkable explosions in the stupendous masses of vapor which are shot out hundreds of thousands of miles from the solar surface. Professor Young also, at this time, established what is known as Doppler's principle as applied to light experimentally, and was enabled to measure the sun's rotation by the displacement of lines in the spectrum.

But, notwithstanding his multifarious labors in the observatory, and at distant places which he visited for observation, Professor Young has also been active as a writer of scientific papers, and as an astronomic teacher. Besides his elaborate courses of instruction to college classes, he has also given courses of popular lectures at Peabody Institute, of Baltimore, and Lowell Institute, at Boston. He has also delivered occasional scientific lectures in different cities, and regular educational courses at Mount Holyoke Seminary, Williams College, St. Paul's School, and several other places. It must be added that he has also found time, within the last few years, to write an excellent popular treatise on "The Sun" for the "International Scientific Series," which is now just issued.

The vigorous movement in the College of New Jersey, at Princeton, for enlarged scientific teaching, which was inspired and directed by President McCosh, led to the choice of Professor Young to take the chair of Astronomy in that institution, and he accepted the invitation in 1877. In 1878 he was in charge of the astronomical expedition organized by the college to observe the eclipse of July 29th of that year, at Denver, Colorado, and in which the party had excellent success. During his residence at Princeton he has maintained his customary activity in pursuing spectroscopic observations in solar physics.

Professor Young has been honored by many recognitions of eminence in his department. He is a member of the National Academy of Sciences, a Fellow and ex-Vice-President of the American Association for the Advancement of Science, an Associate Fellow of the American Academy of Arts and Sciences in Boston, an Honorary Member of the New York Academy of Sciences, and of the Philosophical Society in Philadelphia, and a Foreign Associate of the Royal Astronomical Society of Great Britain.

CORRESPONDENCE.

COLORED MEN IN CHINA.

[We copy the following interesting correspondence from the pages of the "Southern Workman." It contains various significant facts admirably presented.]

SINGAPORE, *May* 10, 1881.

Messrs. Editors.

IN a previous letter I spoke about a negro, S. A. Butler, a resident of Shanghai, China. His career is quite remarkable. His parents were Africans, or pure negroes; his father a preacher in Washington, D. C. He was educated in Paris, and there learned to speak French, Italian, German, and Spanish. I think he has an aptitude for languages. When Mr. Burlingame was appointed Minister to Peking some years ago, he met Butler in Paris, made him his private secretary, and took him to China, where he became familiar with the *spoken* Chinese.

Mr. Burlingame always put him on a footing of social equality. Wishing to go into business, Butler left the American embassy, and took a post in one of the great American trading-houses. Subsequently he went into the service of the Shanghai Navigation Company. For some time past, the Chinese officials and some of the rich Chinese merchants have been watching carefully the operations of the Europeans in steam navigation, supported by European capital. These prudent, careful men determined that, if there was any profit in the trade, the Chinese should have it, and not the *fan qui* (foreign devil). Therefore they began to buy steamships themselves, and to run them to and from their own ports. They organized the China Merchants' Steamship Company. They put their own, and not foreign, money into it. They purchased the Shanghai Company's steamers, and Butler went into their employment. Still, these Chinese, careful and economical as they are, did not understand the business of running steamships, for it is a business which requires special training. These men were cheated by Europeans in the quality of the vessels sold, and they were held in great contempt by Europeans and Americans who kept lines of steamships in the East, and who believed that their dominion over the sea would never be successfully disputed by the "pig-tails."

The Chinese concluded it would be well to employ Europeans, at first, in the most responsible positions. But the trouble has been, that the Europeans have generally tried to rob the Chinese when employed by them. The owners of this new Chinese line, including some of the most influential men in the Chinese Government, put Butler in charge of one of the most important departments of the business, and authorized him to reorganize the service in his own way. He is a natural organizer, one of those men who know how to put things in their proper place, how to put down confusion. He systematized the business, brought order out of chaos, introduced economy, enforced discipline, and rivaled the Europeans in their steamship service. The result is, that after two years' work this Chinese steamship company, instead of running at a loss, has earned over a million dollars net profit. The prospect now is, that it will earn very large annual dividends.

The Chinese official who is at the head of the company told me that they considered Butler not only a man of great ability, but an *honest* man. He said that he was a very safe adviser, and they regarded him as an important agent in the future operations of the company. Now this Chinese company own already thirty-six steamers. They are bidding for the trade of the Pacific Ocean. One of their vessels lately went to San Francisco, and reduced the price of freight to China. The American and European lines are by no means easy at the appearance of this great steamship fleet; no one knows where its operations will stop. As these people learn more thoroughly the steamship business, they will become more formidable rivals to the Europeans, and, as they are content with much less profit than the Europeans, and the business is conducted at their own homes, and not with a distant European basis, it is easy to see that the time is soon coming when the vast trade of the great Pacific Ocean will be in Chinese hands.

Coal is an expensive article in China. Supplies for steamers are brought from Australia and Java. Now, there are immense coal-fields in China. The Chinese will not let the Europeans touch these coal-fields under any circumstances, but they can touch them themselves. Already they have opened a vast colliery about eighty miles from tide-water, at Tientsin; a canal from the mine to the ocean is about finished. The coal is owned by the same people who control the steamship company. This year

coal will be delivered to ships. If the Chinese prefer to consume the coal in their own vessels, instead of selling it to the foreign steamers, it will not take long to wipe out the foreign service, as the cost of the coal will be so much less than that now used by all steamers.

Butler is a leading man in this magnificent enterprise in China.

I have related this incident because it bears on the question of the "color-line," and I write this from a city where the presence of twenty-six different nationalities has obliterated all color-lines. There is a lesson in Butler's life. He fought for his position and won it. He did not sulk for it, or cry for it, or beg for it; he commanded it. He made himself the peer of men about him, and they acknowledged it, as all men will admit, when forced to meet the matter. Men sought him, as they always seek men who have advantages, either in brains or experience. Interested as I am in the negro question, it was to me a most important incident to meet, on the seaboard of the great Chinese Empire, an American negro, educated, capable, doing his work well, and a leader among men.

Several weeks after meeting Butler, I was with the King of the Hawaiians on board the royal yacht of the King of Siam, on the river Menam. On the way to the capital of the country, Bangkok, the yacht stopped for a moment at the custom-house, in order to take on board some officials. I noticed a negro sitting in the stern of a boat, and inquired about him. A merchant said to me: "He is at the head of the custom-house on the river. It is a very responsible place. This negro is a man of considerable education, is honest and capable; so he was appointed to the place, and discharges the duties well." I had no opportunity to speak to this man, but I counted it as another incident of my trip that I had met another negro who was doing credit to himself. I have written this letter for the sole purpose of presenting these facts to the younger colored people in America, that they may know that their race can hold itself if it will.

[Mr. Armstrong adds to the above valuable information a few notes on travel, which we are sure will interest our readers:]

The city of Bangkok contains about four hundred thousand people. Through the center of it flows a large river; from the river canals are cut in every direction; and, while most of the people live on land, very many thousands live on the water entirely. A raft is made of *bamboo*, and tied to the river-bank. A house is then built on the raft. In it one or more families live. The back part of the house, or the part toward the river-bank, is used for living purposes, while the front part, facing the river, is used for stores or manufacturing purposes. One wishing to do some shopping hires a canoe, rowed by two men. This canoe is moved along the river, and stops in front of the houses. The passenger, sitting in it, leans over the side and inspects the articles in the house on the raft; when the trade is over the canoe moves off to another place. It is, in fact, a river-carriage. These water-houses extend for three miles up and down the river. They rise and fall with the tide. In rowing the canoes or boats, the men stand up, facing the bows. The oar is fastened to a stake in the boat, and the rower dips the oar in and pushes it while standing.

About one year ago the Queen of Siam, while passing up the river in a royal barge, was run down by a steam-tug. There were numbers of people standing by, but none of them dared to rescue her, because she was sacred, and could not be touched; so the poor woman went to the bottom. Just before we arrived at Bangkok she was cremated; a vast temple was built for the occasion, and an altar of sandal-wood was erected in the center of it. In this the body was placed, and burned to ashes. Festivities continued for ten days. The total cost of the cremation was above one half million dollars. Cremation is universally practiced in Siam. In many cases the bodies are taken to a temple and exposed in the open air; vultures and carrion-birds come down in dense flocks, and consume the flesh in a few moments. The bones are then burned, and the ashes are scattered in the waters of the sacred river Menam.

The Siamese are a pleasant people, but very lazy. Rice and fish are cheap, and if the people can get this food they will not work. Few of them are forehanded. The consequence is, that the Chinese come in, get the best lands, and do the best part of the business. In the end the four million Siamese will pass away, and the country will be in the hands of the Chinese entirely. It is a case of the "survival of the fittest."

The Chinaman is the New-Englander of the Pacific in his energy and pluck. The Chinaman of the northern part of the empire does not emigrate. Though he is poor, he prefers his mud-hut and his associations to foreign lands; no inducements so far have brought him out of his home. The southern Chinese, living along the coast, in the vicinity of Canton, are the people who emigrate. All who have left are, however, but a fraction of the people in only one province. California holds seventy-five thousand of these people; Australia, perhaps, as many more. What are these numbers to the forty millions of one province alone in south China?

I do not despise their religion. Let no

one despise any religion which contains any good. The central doctrine of their religion is *ancestor-worship*. It is believed that the spirit of the father, or ancestor, wanders about in an unhappy, restless condition, unless it is worshiped. While every Chinaman worships, therefore, the spirits of his forefathers, he is always on the lookout to worship our forefathers. They do it. It is a practical belief, which controls every man's life. The father, while living, is the head of the family, and the profoundest respect is paid to him till he dies. If a Chinaman has money, he would starve himself just as quickly as he would allow his father to go without support. Of the thousands of poor "coolies," or laborers, who have gone from China to the Hawaiian Islands to work on sugar-plantations at eight dollars per month, the majority remit money to their parents; so a missionary in Hong-Kong told me; much of it went through his hands. But the worship of ancestors requires presence at the tomb. So the Chinaman, the moment he has obtained a little money, returns home and worships at the tomb. But every Chinaman must have a son, as I have said. (Of course, under this system of religion early marriages are the rule.) Probably every one of the seventy-five thousand Chinamen in California is a married man, but has left his wife at home. It is clear to me that they would not hesitate to bring them—firstly, if they could afford it; secondly, if they felt secure of property and liberty. The Chinaman has found that, so far as he is concerned, the treatment given him by the proud and Christian civilization of America is more unjust than that of the most despotic of any *taotai* (magistrate) of his native land.

It is said in America: "Oh, these Chinese don't intend to stay; they will not mix with our people. They make money, and go home!" True! But here are some twenty "treaty ports" in China and Japan opened to Europeans and Americans. These people come here, engage in business, make money, and go home. There is not an Englishman, or a Frenchman, or an American, or a German, who does not frankly admit that he came here to make money, and that he shall return home at the earliest possible moment to spend it. Make one of these foreigners believe that his life must be spent here, in the East, and he would look about for his razors.

Here, in Singapore, the Chinese are at the head. Look at the map, and you will see the commanding position of this place, at the southern extremity of Asia. Here the trade of the East centers. The English took it over sixty years ago, when its population numbered about four thousand, all Malays. Now there are one hundred and thirty-seven thousand people, and of these sixty thousand are Chinese, who have come from China, a thousand miles away. All that is valuable, in the way of trade, or business of any kind whatsoever, is in their hands. The Malay can not stand against them for a moment. They outdo him at every turn. Trade from Japan, northern China, the Malaysian peninsula, the vast archipelago of immense islands which include Sumatra and Borneo, stretching away for three thousand miles to the skirts of the Australian Continent, centers here. Thirty languages are spoken, but the Malay is the language of trade, because it is easy to learn. Though, as I say, the Malaysians are of little account here, they were, at the start, the dominant race, and their language became the medium of conversation between the score of races which meet here. Though they have got into the background, in the great struggle, they have left their language to the common use, till some other takes its place.

The similarity of the Malays to the Hawaiians is striking. Though these two nations are five thousand miles apart, and there is no tradition of any intercourse in the ancient days, even the languages have words in common. For death, the Malay says "mate," the Hawaiian says "make"; for eye, the Malay says "mata," the Hawaiian says "muka." For want of thrift, laziness, and supreme indifference to the future, the Malay and Hawaiians are one and the same. The Chinamen will soon be masters of the situation here, and the Malay will submit to it.

W. N. A.

HARVEST-MITES OR JIGGERS.

Messrs. Editors.

THE minute creature about which Dean V. R. Manly asks for more definite information, in your September number, is undoubtedly the *Leptus Americanus*, described and figured by me six or seven years ago in the "American Naturalist." It is a minute, six-legged mite of the genus *Leptus*, now generally recognized as but the larval form of some eight-legged *Trombidium*. Being away from home, I can not now give you the exact references, but may send you more particulars at some future time. Respectfully,

C. V. RILEY.

ALBANY, NEW YORK, *August* 31, 1881.

EDITOR'S TABLE.

DR. FAIRBAIRN AND THE SYNTHETIC PHILOSOPHY.

IT was the aim of Bacon to bring the great divisions of knowledge into unity. Tired of the sterility of the old philosophies, he proposed a new one that should be both a true interpretation of nature and lead to grand utilities. He divined the method, but his imagination outran the resources of his time, and he could not execute it.

Three centuries of science have now made the fulfillment of Bacon's conception not only possible, but an imperative intellectual necessity; and, among the thinkers of this age who have most clearly perceived and most strongly felt the need of attempting this formidable task, is Mr. Herbert Spencer. He entered upon it as a life-work, and has now devoted twenty-five years of unremitting thought to the undertaking. As his system is predominantly constructive—a binding together of different orders of ideas by far-reaching principles—he has called it "The Synthetic Philosophy." It is now in its main features an accomplished fact, and its appearance is probably the most considerable intellectual event of our times. The periodical press is slow to note the significant incidents of its progress, and so nothing remains but for "The Popular Science Monthly" to repair the omission.

The project, in the nature of the case, was extensive, and it was certainly a worthy thing for a man of ability to forego the common aims of ambition, and dedicate his powers to what required prodigious work, and was even then generally thought to be impracticable and impossible. But, noble as was the scheme, it was neither received with the sympathy nor sustained with the liberality that such an undertaking deserved. Nevertheless, Spencer's system of thought has made its way so successfully as to have become of cosmopolitan import before it is yet completed. His elaborate works have been reproduced in all the leading modern languages, and they are making a powerful impression upon the cultivated mind of the different countries where they are circulated. They are ably criticised in the leading reviews of these countries, and books are multiplying on every hand, directed to the exposition, defense, and refutation of their doctrines.

We have referred to the unfavorable reception of his system. That his views should have met with a formidable resistance was natural and proper, but criticism did not stop here. The attacks of reviewers were too often accompanied by gross personal disparagement. His adversaries, assuming themselves to be the guardians of great and sacred interests, often wrote with passion, and indulged in the tone of depreciation wholly foreign to the purposes of honorable controversy. The critics are, however, beginning to find that nothing is gained in the long-run by such unfairness. The system pronounced worthless and impotent, or potent only for mischief, is steadily gaining upon the world's favorable appreciation. Spencer has been again and again ostentatiously "crushed," and all men called to witness how the dust of his unsubstantial reputation has gone to the winds. Yet there stands the solid fabric of his labors unharmed, the stronger for every attack, and becoming more stable with each addition as its author steadily proceeds with his task.

What we are now called upon to

note is that the abler men who have latterly ventured to cope with his thought no longer disparage him. In this respect there is a marked change of tone on the part of his critics. They recognize that his work has in it great elements of valuable influence, worthy of cordial praise and even of emphatic eulogy.

This more liberal spirit is well illustrated in a recent English criticism of Spencer's doctrines that is attracting attention. Principal Fairbairn, of Bradford, was appointed to deliver the "Muir Lectures" at the University of Edinburgh last winter, and recognizing the growing influence of the synthetic philosophy he devoted three of these lectures to an examination of it. They were reported at the time, and awakened so much interest that the author was led to make an extended restatement of his case, which has appeared in the July and August numbers of the "Contemporary Review."

Dr. Fairbairn is a subtle and thoroughly trained metaphysician, and he devotes himself mainly to an attack upon the introductory portion of Spencer's scheme, where he discusses the limits of knowledge to find the true sphere of philosophy. With Dr. Fairbairn's general argument we have here no concern, but are interested in its opening passage, which reads as follows:

> Mr. Herbert Spencer's philosophy has at least one conspicuous merit—it can claim to be the most comprehensive, or rather ambitious, of English philosophies. It is, in its psychology, distinctively English and empirical; but, in its spirit and endeavor, distinctively encylopedic and transcendental. In many respects its constructive and comprehensive character entitles it to cordial admiration and praise. Its outlook, backward, forward, and outward, is so immense that it powerfully affects the imagination, which the traditional philosophy of England has, with the splendid but only the more illustrative exception of Berkeley, been too prosaic and narrow to touch or to stir. To conceive a system so positive and universal as Mr. Spencer's is in itself an education to an age, and its extraordinary influence is an evidence that the modern intellect is neither so skeptical nor so critical as it is said to be, but loves, as intellect ever has done, to believe a system, stated in terms it thinks it understands, that promises to explain the universe presented to its senses and represented in its thought. The English mind has been rather inclined to make merry over the philosophies of Germany, especially the Hegelian, which has so adventurously essayed to fit the universe into its dialectic network; but the approbation which has greeted Mr. Spencer's attempts at a "synthetic philosophy" is proof enough that the English contempt for transcendentalism is due to insular peculiarities, not to say ignorance, rather than to intellectual disability or insufficient sympathy with constructive aims. His system, indeed, seems so little metaphysical, so concrete, intelligible, real, it so speaks the language of science, is made so striking by brilliant generalizations, and so vivid by abundant, even superabundant illustrations, that it has come, to a people inclined by their mental habits to despise metaphysics and respect science, almost as a revelation of the true nature and method of creation.

This is a novel strain for an adversary of Spencer. It is no small compliment to pay a system of thought that its largeness and power are attested by its influence upon the national mind, and that even during its promulgation. It may seem ungracious not to accept so generous a statement as wholly satisfactory; but, in accounting for the "remarkable influence" ascribed to Spencer's system, Dr. Fairbairn seems strangely to have missed what we regard as its most important element. He recognizes its ambitious claims and its specious character, which make their appeal to a deficient national culture; but he was not ignorant that this system has in it also sterling elements which have made their successful appeal to the most sober and thoroughly instructed minds of England. Admissions made in the course of his discussion, if placed at its threshold, would have very materially altered the complexion of the opening passage we have quoted.

Although combating various of Spencer's positions, chiefly on the metaphysical side, Dr. Fairbairn fully accepts the doctrine of evolution. Many give it a cautious and qualified approval in the lower sphere of life. Dr. Fairbairn takes it without reservation as a comprehensive law, true not only in the domain of inferior life, but also in the higher sphere of humanity, and emphatically in the realm of religious sentiments and ideas. He says: "There is to be no attempt here to question or deny the doctrine of evolution; it is indeed frankly accepted. . . . The creational method is here held to be evolutional. Its history narrates a progress and exhibits a process best named developmental. Without this notion a philosophy of religion were impossible, for without it there could be no scientific study of man and his religions. We can not refuse to apply the principle or idea that underlies and vivifies the study of man in history to the interpretation alike of man and nature, to the master-problems that relate to their being and becoming, to their birth and growth."

Now, this great principle is the pervading and characteristic idea of the synthetic philosophy. It is there first expounded as a universal law, developed as a method of thought, and carried out in its main applications. Dr. Fairbairn holds it to be true, and a truth of such moment, that its establishment makes an epoch even in the study of religion. But is this fact that Spencer's system has a great and all-influencing truth at its foundation which he has so profoundly mastered that he has been enabled to throw it into philosophic form—is this fact to count for nothing in estimating the elements of its admitted "remarkable success"? What kind of a notion has Dr. Fairbairn of the value which his readers attach to the quality of truthfulness in systems of thought submitted to their judgment? We propose to show that what he has here overlooked is precisely that attribute of Spencer's system which has been most potent in commending it to the best intelligence of the age. It not only "speaks the language of science," but it embodies the truths of science, it organizes the principles of science, it conforms to the methods of science, it is a scientific philosophy; and the hostility it has encountered on the one hand and the favor that has been extended to it on the other are due to its supposed identification with science in spirit, substance, and method.

Dr. Fairbairn's omission to recognize this fundamental trait of Spencer's system, when accounting for its extensive influence, may not have been intentional, but it is significant. What is the state of mind that could allow such an oversight? It is simply the general state of mind exhibited by our so-called cultivated classes toward scientific truth. Let us see what this is.

Opposition to science is not the exclusive reproach of any one school of thought; it has been manifested by all. Theology withstood science, because it was itself identified with the old erroneous explanations of nature. Philosophy made a stand against science, because science circumscribed its field and subverted its ideals. Literature strove against science, because of its devotion to fact and its supposed unfriendliness to imagination. Art resisted science as unfavorable to the inventive and creative spirit. Science studied matter to understand its mysterious processes and discern its laws; the schools of culture all contemned the occupation of mind, and shrank from it as a descent into groveling materialism. Philosophy was most potent in its opposition, because it gave law to education and gave reasons to theology, literature, and art.

The antagonism of so-called philosophy to the scientific spirit was inevitable. In the childhood of knowledge it entered upon speculations which could

yield no valid results, and came at length to consider that valid conclusions, being impossible, were undesirable. But, as active thought could not be stopped, it was concluded that the virtue of philosophy consists merely in the mental exercise it involves. And, as philosophy had proved useless as a means of arriving at assured truth, its uselessness was claimed to be a merit. And so utility, or the value of results attained, both in themselves and in their practical service to man, was explicitly repudiated. Alike in old Greece and in modern Germany—from Plato to Hegel—this has been the philosophic teaching, and we have seen the doctrine solemnly promulgated in our own times. Sir William Hamilton, as is well known, opens his lectures on metaphysics and logic with a formal defense of it. He maintains that the pursuit of knowledge by man for any end beyond himself—that is, for any practical benefit, private or public—is nothing less than debasing. It is a degradation of the ideal of scholarship. He says that the attainment of truth is not the proper object of mental activity, but the pleasure of the pursuit of truth. To seek is noble; but to seek successfully—that is, to find the object sought—is a calamity, because it ends the gratification of the search. The founder of a modern and influential school of philosophy ransacks antiquity and ranges down all the dark ages after authorities who have held this doctrine, and his case is fully made out.

Now, when this old philosophical notion that truth, for itself and for its uses, is not the proper end of study, is still theoretically maintained in our colleges and universities to be the first law of all liberal education, we need not be surprised at the extent of the ignorant prejudice against science, and that the influence of this prejudice should still be widely manifested. Illustrations of it appear everywhere. We pick up the last number of "Scribner's Monthly," and this is the way it talks to its hundreds of thousands of readers:

> We doubt whether what we call literature will ever be indebted to science or what is recognized as "the scientific spirit" for anything good. Science deals with matter, its essence, laws, phenomena. Its tendency is to materialize everything. Life itself is evolved from matter. Its "promises and its potencies" are found in that. The tendencies of science are to count God out of the universe, to deny immortality, and the existence of mind independent of matter, and to believe nothing that can not be demonstrated. Hard material facts are the things with which science deals, and it refuses to have to do with anything else. It refuses to recognize the existence of anything like imagination except in a scientific way. Imagination is a product of molecular action in the brain. Science must necessarily deny to this faculty of the soul any legitimate functions because it can not follow a scientific method, and because it denies the existence of the realm in which it is most at home. Imagination must have an over-world in which to spread its wings, or it can not fly. To bind itself to demonstrable facts and to tie itself to a scientific method would be to commit self-destruction. To circumscribe the horizon of the poetic faculty is to clip its wings, or, rather, to deny it space for action. It is a faculty that demands illimitable space, illimitable time, illimitable freedom of invention, release from bondage to the material and real, and liberty to explore the spiritual and the ideal. Any influence or power which interferes with this liberty in any direction is a foe to poetry and a curse to literature.

Crude and ridiculous as this statement is, it represents a widespread feeling. The fact is that, so long as science sticks to the manipulations of matter, it is let alone; but, when it comes forward with its revelations of the constitution of nature, and asserts that these must in future affect all the higher departments of thought, it is met with denunciation from every school of cultivated ignorance which grew up before scientific knowledge arose. This explains the ill-will of multitudes toward Spencer's system. It represents science in its most obnoxious aspect, in carrying its method into the field of general ideas.

But we have here also an explanation of the powerful hold of this system on the instructed and independent mind of the period. Dr. Fairbairn truly says that "to conceive a system so positive and universal as Mr. Spencer's is itself an education to an age." But more than this is true; for if, as confessed, this system has attained a "remarkable influence," that influence has actually been an educational power on a great scale. What is it that Spencer has brought to his contemporaries which they had not before, and which is so adapted to the general condition of thought that barely to conceive it is "an education to an age"? Dr. Fairbairn having omitted the most important answer to this question, we are now prepared to give it for him.

Mr. Spencer, as we have intimated, has first given to the world a philosophy that is an outgrowth of science, and answers the clear requirements of advancing knowledge. The older philosophy, with its lofty scorn of truth as an end and its emptiness of everything useful, had so trifled with the commonsense of mankind that its very name fell into reproach. Spencer has redeemed it and vindicated its rightful supremacy by showing that its sphere is the realities of nature and experience, and its function to formulate the deepest interpretation and the widest ascertainable truth of the universe. Philosophy, as he views it, is not merely a skillfully reasoned body of speculation; it is nothing, if not true—nothing, unless it compels assent as the highest of verities. Science passes into philosophy as it furnishes generalizations from all orders of phenomena which merge into truths that are universal. Claiming no ideal perfection or completeness, it gathers established principles from all scientific sources into systematic expression, and thus acquires a harmony as perfect as the discovered harmonies of nature, and a unity as absolute as the demonstrated unity of the universe. The formation of such a philosophy implied a reorganization of knowledge that should bring its hitherto diverse branches into closer relations of dependence, the separate orders of truth into higher coördination, and thus give a strength to the fabric derived from the validity of its scientific elements. Such a philosophy must widen its scope and grow ever more consistent, more congruous, and more comprehensively unified with every extension of knowledge. Who expects that the transcendental and metaphysical systems will ever be brought into mutual confirmation or any possibility of agreement? Concord has only given us a new illustration of the old and hopeless discord. Spencer's philosophy has made its auspicious way because it gave to the age what it imperatively needed. Men were wearied by futile speculation on the one hand, and appalled by the growing details of science on the other; and they wanted a higher synthesis of verified truth, a constructive philosophy of science. It is as a new *organon* of knowledge that Spencer's philosophy has gained its commanding influence over the active mind of the period, and it is this trait that has made it one of the most widening, elevating, and potent educative agencies of the age.

Another feature of the synthetic philosophy, though implied in what has been said, is so important in accounting for its "remarkable influence" that it requires to be brought out more explicitly. Spencer's system is sharply contrasted with preceding philosophical systems by its recognition of the great value of knowlege for useful ends. His philosophy is animated by a grand utility. Holding that truth is to be supremely valued for its own sake, and that philosophy is justified in its truth alone, Mr. Spencer finds that the highest truth involves also the highest good, and his system thus becomes nobly tributary to the advancement of human welfare. Science has sufficiently exem-

plified the worth of mental acquisitions for practical purposes, and points to its conquests over the material world as proofs of its useful services to man. But it is a far higher service to have disclosed the true method of nature and determined man's real position in the universe; because only as these are understood can human conditions be permanently improved. Spencer's philosophy assumes this higher sphere of beneficent influence, and throughout its whole development it bears upon the final and regnant problem of the regulation of human conduct. Each division of his system has its intrinsic interest as a new exposition of principles determined by the great reorganizing law of evolution; but "First Principles," the "Principles of Biology," the "Principles of Psychology," and the "Principles of Sociology," are only so many foundations for the ultimate exposition of the "Principles of Ethics." The constitution of nature as an ever-unfolding order, the laws of life, the laws of mind, and the laws of social relation, are successively expounded with a view to their final bearing upon the right and wrong of human actions.

The inspiration of these labors was a profound interest in the moral welfare of society; and there are many who can now appreciate the sagacious forecast that could discern an approaching emergency of thought for which it was imperatively necessary to prepare. While yet the idea of evolution was derided as a fanciful conceit of visionary minds, Herbert Spencer knew that it was soon to become the governing law of the world's best intelligence. He saw that, among the great changes that would follow, the traditional theories of morality would be sure to suffer irreparable damage, and that morality itself might lose its force if not fortified by a new authority. The synthetic philosophy was accordingly laid out in its complete logical order more than twenty years ago, to meet the inevitable emergency that has now arisen, and the wisdom of this prescience is attested by the eager interest with which the "Data of Ethics" was lately received in every civilized country.

The aim of Spencer's philosophy is, therefore, to organize that scientific knowledge of nature and human nature which shall be most valuable for guidance, alike of the individual in his personal and private sphere, and of society in its relations with the individual. This system establishes the principles by which the freedom of the citizen and the duty of the state are determined. There, as nowhere else, we are shown the growth and conditions of human liberty, and the forces that have hindered and the forces that have promoted its progress.

Nor has the reader to go far for evidence of what we say. The last installment of his system that Spencer has given us is luminous with new instruction upon this subject. The article on "The Militant Type of Society"—long, but not too long—printed in the present number of the "Monthly," exemplifies in an impressive if not a startling way the obstructive agencies of social progress. A succeeding article on "The Industrial Type of Society" will complete the view by showing what causes have been most powerful in producing beneficent social and political effects. The reader will find in those papers exemplifications of the enlarged utility which dominates Spencer's system, and for which he will look in vain in any preceding philosophy.

These, then, are the leading reasons why this system of thought has attained its "remarkable influence," and merely to conceive which "is itself an education to an age." But if the bare conception of it, even before it is finished, has so benign and improving an influence, what may we not expect from it when it is studied and understood, and becomes a power in the public

mind? Self-education is the only true education, and, if young men want a liberal education of practical value, let them master the synthetic philosophy and be their own teachers.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES.—NO. XXXIV.

THE SUN. By C. A. YOUNG, Ph. D., LL. D. With numerous Illustrations. D. Appleton & Co. Pp. 321. Price, $2.

THE first thing we have to say about this attractive and admirable little volume is, that it was sorely needed. It was wanted, not only because of the great interest of the subject, but because we have no work in English that deals with it in any satisfactory shape for general use. Proctor's book on the sun, notwithstanding its author's astronomical reputation, is, after all, little more than the compilation of a professional book-maker. He has used his copious materials freely, and made his book too large and expensive, and too crowded with matter of secondary interest, to meet the popular requirement. It has, therefore, not been held as even worth stealing. The great treatise on the sun, of the late Father Secchi, of Rome, though written by an eminent astronomer who has worked at the subject extensively himself, is likewise too voluminous, and also too scientific, for general purposes, and it has accordingly not been thought worth translating into English. The book of the Frenchman, Guillemin, though small enough, is all too popular, and is so variously deficient as to have no true standing. A new book, compact in form, and thoroughly trustworthy for reading and reference, was greatly needed, because the knowledge that has grown up in recent years concerning the great central body of the solar system is not only of exceeding interest, but is such as well-instructed people can not afford to be without.

But it was no easy thing to get the book required. First-class scientific men are always pressingly occupied, and they very rarely take to book-making unless for the promulgation of their own views. The managers of the International Scientific Series have, therefore, been fortunate in securing a strong book on this subject, although they have had to wait a good while for it. Yet those who have been long and impatiently expecting it will now be rewarded for their waiting. Professor Young is an authority on "The Sun," and writes from intimate knowledge. He has studied that great luminary all his life, invented and improved instruments for observing it, gone to all quarters of the world in search of the best places and opportunities to watch it, and has contributed important discoveries that have extended our knowledge of it. The reader who glances at the summary of his life-work, given in an accompanying biographical sketch, will see why, of all men, he was perhaps the best prepared to report on the present state of solar knowledge. He, at all events, had the first qualification for the task, because he knew whereof he affirmed.

And he has executed the work in a manner worthy of the subject, and of his reputation. He has stated what is known about the sun in a form excellently suited for general apprehension. It would take a cyclopædia to represent all that has been done toward clearing up the solar mysteries. Professor Young has summarized the information, and presented it in a form completely available for general readers. There is no rhetoric in his book; he trusts the grandeur of his theme to kindle interest and impress the feelings. His statements are plain, direct, clear, and condensed, though ample enough for his purpose, and the substance of what is generally wanted will be found accurately given in his pages. The key to his treatment is contained in the following passage from the preface: "It is my purpose, in this little book, to present a general view of what is known and believed about the sun, in language and manner as unprofessional as is consistent with precision. I write neither for scientific readers as such, nor, on the other hand, for the masses, but for that large class in the community who, without being themselves engaged in scientific pursuits, yet have sufficient education and intelligence to be interested in scientific subjects when presented in an untechnical manner; who desire,

and are perfectly competent, not only to know the results obtained, but to understand the principles and methods on which they depend without caring to master all the details of the investigation. I have tried to keep distinct the line between the certain and the conjectural, and to indicate as far as possible the degree of confidence to be placed in data and conclusions."

It is unnecessary further to dilate on the merits of this volume, especially as the readers of "The Popular Science Monthly" are not unacquainted with Professor Young's skill in scientific exposition; nor will it be possible, in any notice, to illustrate the richness of these pages in striking facts, felicitous illustrations, and lucid explanations, concerning the constitution, astronomical relations, and stupendous influence, of the solar body. There is an introduction on "The Sun's Relation to Life and Activity upon the Earth." This is followed by a systematic discussion of the main problems of solar phenomena, in a succession of chapters treating of "The Distance and Dimensions of the Sun," the "Methods and Apparatus for studying the Surface of the Sun," "The Spectroscope and the Solar Spectrum," "Sun-spots on the Solar Surface," "Periodicity of Sun-spots, their Effects upon the Earth, and Theories as to their Cause and Nature," "The Chromosphere and its Prominences," "The Corona," and "The Sun's Light and Heat." The concluding chapter is an excellent "Summary of Facts and Discussion of the Constitution of the Sun." An appendix is added, which has been contributed by Professor Langley, one of the most zealous and successful American cultivators of solar astronomy. It presents certain important views, which this investigator has reached, with regard to the light and heat of the sun.

Professor Young's book is not written in rhyme, and does not profess to be "poetry." Perhaps it is inimical to poetry, as it deals with hard scientific material facts, and, if these are truly incompatible with poetic thought, the book will be open to the maledictions of all who consider error better than truth for the purposes of the poetic mind. But this, at any rate, may be said: no one can read Professor Young's book without recognizing very clearly that the sun, as interpreted by the science of to-day, is a far grander and more impressive object of thought than was the sun of a century or two ago. Milton traversed the universe of his time with intrepid imagination, but what was his conception of the "powerful king of day," compared with the conception of the sun which science has now shown to be true? The poetic imagination has never pictured anything to be compared with the sublimity and unspeakable grandeur of the all-regulating, life-giving star round which we are revolving, and which, so far as the human mind is concerned, science may be said to have created. Has not science, in this and kindred exploits, given a transcendent enlargement to the sphere of the imagination? We do not believe that ignorance is the mother of legitimate devotion or of genuine poetry; and those who think that the truth-seeking faculty in man, which, in a certain aspect, is simply occupied in extending the realm of wonder, and disclosing the beauty, the harmony, and the magnificence of Nature's operations, is the enemy of real poetry, have a good deal yet to learn about the subject. It will damage no sound poet to absorb the contents of Professor Young's book.

CHINESE IMMIGRATION IN ITS SOCIAL AND ECONOMICAL ASPECTS. By GEORGE F. SEWARD, late United States Minister to China. New York: Scribners. 1881. 8vo. Pp. xv–421. Price, $2.50.

RESERVING for a possible future volume the question of "the political and commercial issues" involved in the Chinese question, Mr. Seward limits himself in the present work to its social and economical aspects, as those which are likely to determine the legislative action of the country. These aspects he considers under the following heads: 1. The number of Chinese in the United States; 2. The material results of Chinese labor in California; 3. Objections to Chinese immigration; and, 4. Fears of an overflowing immigration.

And—1. The number of Chinese in this country has been habitually over-estimated by the anti-Chinese partisans. In California it was common to hear it said, a few years ago, that there were "more Chinamen than voters" in that State The facts have

been carefully studied by Mr. Seward from the customs statistics of arrivals and departures, and from the recent census; and it turns out that there are no more than ninety-seven thousand Chinamen in the United States, of whom one half live in California, where they form about one in seventeen of the population, and enjoying such provisional security of life and property as the other sixteen see fit to permit them. During the past few years the number of resident Chinese has somewhat diminished, owing in part to the resident Californian's conviction, which he has not failed to express in practice, that the pagan element in a Christian population should be discouraged. This conviction, if we may trust the evidence of Commissioner John A. Swift (p. 250), would seem to be increasing. "In 1852," says Mr. Swift, "the Chinamen were allowed to turn out and celebrate the Fourth of July. In 1862 they would have been mobbed. In 1872 they would have been burned at the stake." This spirit may be profitably contrasted with that of a memorial written by a Chinaman resident in this country (p. 245): "If the spirit be noble and good, although the man be poor and humble, we honor and love him. But we affirm that the people of your honorable country dislike the Chinese because they see the plain appearance and the patched clothes of our poor, and do not think how many spirits there are among us whom they could respect and love."

2. The results of Chinese labor in California are considerable. In railroad-building, in farming, fruit-culture, and the reclamation of swamp-lands, in mining and manufacturing, and in such special industries as cigar- and shoe making and laundry-work, they have been of particular service. Governor Low estimated that four fifths of the grading on the Central Pacific Railroad was done by Chinese laborers. Mr. Charles Crocker, one of the builders of that road, testified before the Congressional investigating committee: "If I had a big job of work that I wanted to get through quickly, and had a limited time to do it in, I should take Chinese labor to do it with, because of its greater reliability and steadiness, and their aptitude and capacity for hard work. They are equal to the best white men." On this point, however, there is some discrepancy in the evidence, one estimate being that three Chinamen are needed to do the work of two first-rate white laborers. In domestic service the Chinese hold an unquestioned place. No one who has had experience of them will underrate their intelligence and faithfulness. A great want of the American community is that of good house-servants. To what is the lack of supply due? To our liberal institutions, the spirit of which makes domestic service of any kind seem degrading in American eyes, and even after a short term of residence in the eyes of the European immigrant. But, in the case of the Chinese immigrant, who, it is complained, does not "assimilate" with us, this moral condition is not set up. This lack of assimilability may be owing to our inquisitorial treatment of him; but it will be time enough to decide whether he will assimilate, or wishes to assimilate, with us, when we shall have admitted his rights as a human creature. Meanwhile, as Mr. Seward might have pointed out, it is precisely because he does not assimilate that he makes the best house-servant that our community has yet seen. He has no thought of becoming an alderman or a mayor, or of being promoted from the kitchen to Congress. He comes to do the day's work for the day's wages; he does it faithfully and contentedly, and there the matter ends. If American politicians have taken pleasure in the rapid assimilation of the Celtic contingent in our immigration, American housekeepers, on the other hand, would welcome a class of servants a little less in haste to assimilate, and a little more disposed to serve. If the American home is in danger of extinction, as some foreign critics have predicted, and our families are to be driven into hotels for the lack of cooks and chambermaids, it will not be because a race of real servants could not be brought from China.

3. The main objection to Chinese immigration, as already intimated, is political, and not social. Political equality, political availability, have been made the test, and unjustly so. Mr. Seward reviews other grounds of objection in detail, and concludes by saying: "I dispute earnestly the statement that they are a servile class; that

they interfere with the labor of our people; that they send money out of the country; that they have set up a *quasi* government of their own upon our soil; and that they do not accommodate themselves to the requirements of our life." That they are a vicious people has been argued from their sexual immorality, which, however, is not greater than would be expected in a celibate community like that of the Chinese in California.

4. As to the fear of an overflowing immigration of the Chinese, in case immigration should be freely permitted, the fact is that the Chinese are not, and never have been, a migratory people, but are, on the contrary, more strongly attached to their native soil than the people of any Western nation—except, perhaps, the French. They have not even "settled up" their own outlying districts, as Formosa, central and northern Manchooria, and the vast regions of inner Mongolia. And it is to be added that the demand for Chinese labor in California lessens yearly as the country is cleared up. The whole question is one that could safely be left to the operation of natural laws, social and economic. As it stands, it has been sadly muddled by governmental interference.

Mr. Seward does not deal with the philosophic aspects of the question, though they are constantly suggested by his book. One can not leave it without perceiving, for instance, the strong side of the Chinese conservatism. The rulers of China see that conservatism, ancient routine, the established order of things, mean a condition of stable equilibrium for the people, or, in the terminology of our day, that the individual nation is adjusted to its environment; and they wisely refuse to break up this adjustment by the too hasty introduction of foreign works or devices of any kind. At the present writing the Chinese policy seems to us a sounder one than that of Japan, where the changes introduced within twenty years are such as to imperil the institutions which had been perfecting themselves for many centuries. But inquiries like this are outside of the province of this work; meanwhile, Mr. Seward has given us a full, intelligent, and temperate treatment of the whole question of Chinese immigration, which, he thinks, within bounds, would be wisely encouraged.

DISCOVERY OF PALÆOLITHIC FLINT IMPLEMENTS IN UPPER EGYPT. By Professor HENRY W. HAYNES. Pp. 5, with Seven Plates.

MM. BRUGSCH, Mariette, and Chabas, have denied that any palæolithic implements occurred in Egypt; M. Arcelin, Dr. Hamy, M. Lenormant, the Abbé Richard, and Sir John Lubbock, have asserted that they have found them. The general impression has been that the stone implements of Egypt, which were always used ceremonially in the embalming process, were all neolithic, and of historic times. The author went to look for himself, and claims that he found near Cairo, and near Helouan, in the desert, and in the valley west of Thebes, palæolithic implements of the true St. Acheul type, with the other forms that usually occur with them, some of which were exhibited in Paris, and have been referred to in articles by M. de Mortillet and himself, which have been published in "The Popular Science Monthly." Sixty illustrations of the implements are given in the plates to the present work.

A MEMORIAL OF JOSEPH HENRY. Published by order of Congress. Washington: Government Printing-Office. Pp. 528.

A PUBLIC commemoration of the services of Joseph Henry in behalf of the Smithsonian Institution and of scientific progress in America was held, under the auspices of the Regents of the Institution in conjunction with the two Houses of Congress, on the 16th of January, 1879. The present volume contains the *verbatim* report of the proceedings on the occasion, published under the direction of Congress, together with the addresses which were delivered at other memorial meetings, of Princeton College, and several scientific societies. In the memorial services at the Capitol, Professor Asa Gray, in behalf of the Board of Regents, gave a brief statement of the life, studies, experiments, discoveries, and general scientific work of Professor Henry; Professor W. B. Rogers made a special review of his electrical studies and discoveries. Mr. Garfield showed how, when

all others had failed, he solved the true meaning of Smithson's bequest in a way of which the world has recognized the correctness, and Mr. S. S. Cox how he had labored to give that meaning effect; and General Sherman bore testimony to Professor Henry's personal qualities as a scientific teacher and guide; while the Hon. Hannibal Hamlin demonstrated the satisfactory manner in which he had managed the financial and material interests of the institution, and the excellent condition in which he left it. To these minutes are added a memorial discourse by Samuel B. Dodd, and reminiscences by Professor Cameron, at Princeton College; the discourse of President Welling, of Columbian University, before the Philosophical Society of Washington; the discourse by William B. Taylor before the same body on "The Scientific Work of Joseph Henry," full and elaborate enough to make a volume by itself; and addresses by Professor J. Lovering, Professor Simon Newcomb, and Professor A. M. Mayer, before the American Academy of Arts and Sciences, the National Academy of Sciences, and the American Association, respectively. The special subject of the last address is "Henry as a Discoverer." The recognition of the simplicity, gentleness, and strict integrity of Professor Henry's character is a distinct feature in all of the addresses.

ANNIVERSARY MEMOIRS OF THE BOSTON SOCIETY OF NATURAL HISTORY. Published in Celebration of the Fiftieth Anniversary of the Society's Foundation, 1830–1880. Boston: Published by the Society. Pp. 635, with 44 Plates. Price, $10.

THE Boston Society of Natural History, having completed its fiftieth year in 1880, celebrated the event by a jubilee meeting on the 28th of April, and by the publication of this noble volume, containing the history of the Society and a number of special scientific papers. The book is a worthy memorial of the work of one of the oldest and most active of American scientific societies, and does justice to the part which that body has taken in the promotion of scientific research and the extension of scientific knowledge in the United States. The history of the Society is given from year to year, and by periods of ten years each, with a minuteness of detail which records every gift of specimens, every trouble from the ravages of insects in the museum, and even such matters as the passage of a resolution forbidding smoking in the room—things which may seem superficially of little interest, but which are instructive enough to justify their place, for they show how the life of the Society was maintained, what mistakes it made, and what difficulties it had to encounter. These features and accidents are such as are common to all similar societies, and this frank setting of them forth, as lessons of experience by which other bodies may be guided to the wisest management, is a good work. The present Society was preceded by the Linnæan Society of New England, which was founded in 1814, and was the first organized effort to excite the interest of the American public in natural science. It had a successful and prosperous career for several years, but finally died out because it depended entirely upon the voluntary effort of men whose time was already wholly occupied with their own business for its maintenance and the care of its collections. The museum—a fine one for the period—was given to Harvard College, which promised to provide a building for it and did not, and consequently it was nearly all lost. The Boston Society of Natural History was founded in 1830, on the same plan as the Linnæan Society, and by the same leading men, and would probably have met the same fate, but that it came into the possession of a fund sufficient to put it on a firm footing and enable it to employ special curators for its collections. Its early history is an epitome of the earlier development of scientific thought in this country, and, in its later history, it has kept pace with the broadest expansion of that thought. Its contributions to knowledge, as related in the yearly records, appear important and valuable when regarded in detail, and give, when summed up, occasion for satisfaction that we have had such a body laboring so long and so industriously to lead the public to higher objects of study, and that its vigor is still waxing. Not the least important of the works of the Society has been the institution of the practical scientific lectures to teachers, with object-illustrations, for the

purpose of introducing better methods of instruction into the public schools. Besides the annals of the meetings and work of the Society, the memorial contains notices of the lives and labors of its members, officers, and benefactors, who have died during its existence, accompanied with nine portraits. In the "special scientific papers" are included articles on "The Classification of Lavas," by N. S. Shaler; the "Species of Planorbis at Steinheim," by Alpheus Hyatt; "The Devonian Insects of New Brunswick," by S. H. Scudder; "The Cedar-Apples of the United States," by W. G. Farlow; "A Structural Feature in Deep-Sea Ophiurians," by Theodore Lyman; "The Development of the Squid," by W. K. Brooks; "Limulus Polyphemus," by A. S. Packard, Jr.; "The Milkweed Butterfly," by Edward Burgess; "The Development of Double-headed Vertebrates," by Samuel F. Clarke; "The Tongues of Reptiles and Birds," by C. S. Minot; "A Special Anatomical Study in Birds," by E. S. Morse; "The Crania of New England Indians," by Lucien Carr; and "The Feeling of Effort," by William James.

INDIGESTION, BILIOUSNESS, AND GOUT IN ITS PROTEAN ASPECTS. Part I. INDIGESTION AND BILIOUSNESS. By J. MILNER FOTHERGILL, M. D., Member of the Royal College of Physicians of London. New York: William Wood & Co. Pp. 320. Price, $2.

THIS is a book for the medical profession, and a very valuable one, as it is based upon the latest scientific knowledge brought to the test of practice. Physiology and animal chemistry have made sure and very important advances in late years, so that the fundamental changes of digestion, nutrition, and excretion are far more clearly understood than formerly. Physiology, treating of the normal operations of the living system, is the basis of all knowledge of perverted or diseased action, and this book is written from a strictly physiological standpoint. It opens with an excellent history of the processes of natural digestion in their several stages, including, of course, the constitution of foods, and their transformations under the influence of the digestive secretions. From this point the author passes on in successive chapters to the consideration of Primary Indigestion, Artificial Digestion, Ferments, Tissue Nutrition, Secondary Indigestion, Diet and Drink, the Functions of the Liver, Liver Disturbance, Biliousness, and the Medicinal and Dietetic Treatment of Liver Derangements. The subject will be pursued in another volume devoted to the consideration of Gout.

The author holds that disturbances of digestion are terribly on the increase in the present day, and he adds a valuable appendix on "the failure of the digestive organs at the present time," and on the "failure of nutrition in children."

We have said that this volume has been made for physicians, but it would be a mistake to infer that it had been exclusively prepared for them, and will not be of great value to non-professional readers. The information it contains ought to be widely diffused, and persons of ordinary intelligence can learn a great deal from it that will be of the highest practical use. It can not, of course, be mastered without study, but no subject will better repay careful attention. The general ignorance in relation to foods, their composition, preparation, and physiological effects, and the causes of indigestion in its various forms, is something lamentable, and the daily practice that results from this ignorance is almost heathenish. There are, moreover, abundance of quackish books on these subjects which so mislead people that they are worse than nothing. It is, therefore, important that the circulation of really valuable volumes on such topics as the one before us should be in every way promoted.

RANTHORPE. By GEORGE HENRY LEWES. New York: William S. Gottsberger. Pp. 326. Price, 75 cents.

THERE are not many novels that survive their generation; they generally fall into an early and deserved oblivion. Mr. Lewes was not eminent as a novelist, his efforts in this direction being, indeed, regarded rather as failures than successes; but, after the lapse of a generation, his first essay of this kind reappears in a new and American edition. Mr. Lewes began with novel-writing, went on into dramatic composition, passed from this to philosophy, and finally emerged in the field of science. His novels,

therefore, do not embody the results of his long and varied studies, but they have the interest of being his first and freshest intellectual work. "Ranthorpe" was written at the age of twenty-five, though it was published five years later, in 1847. He says, in the preface, after acknowledging the defects of the book: "That the faults are not *more* numerous is owing to the admirable criticisms of two eminent friends, who paid me the compliment of being frankly severe on the work submitted to their judgment. Sensible of the kindness in their severity, I have made them what, for an author, must be considered as a magnificent acknowledgment—I have adopted all their suggestions"!

It is not difficult to explain why "Ranthorpe" was not a success in the ordinary sense of a popular novel; but the explanation will probably give the reason why it has been since recalled to the attention of the reading world. It was of too didactic a quality to suit the tastes of novel-readers in search of mere sensation. It is full of moralizings, and, although the topics are secular enough, it is rather preachy. But there is a good deal of wisdom in it that is not without its use. The hero of the book runs a literary career, goes first into poetry and fails, then into the drama, and his tragedy is d——d. The main interest of the volume is in the copious side discussions on the causes of failure in literary adventure, and we have a vivid and readable illustration of ideas which the author subsequently developed in his review articles on "The Principles of Success in Literature." From this point of view the book is instructive, while the plot keeps up the reader's interest in the usual way.

SEWER-GAS AND ITS DANGERS; with an Exposition of Common Defects in House-Drainage, and Practical Information relating to their Remedy. By GEORGE PRESTON BROWN. Chicago: Jansen, McClurg & Co. Pp. 242. Price, $1.25.

THIS work is the result of investigations made by an impartial inquirer in the city of Chicago into the extent to which sewer-gas is responsible for sickness and discomfort. An amazing prevalence of defects of all kinds in the construction and working of the house-drains was discovered, of which the dwellers in the houses generally seemed unconscious. The conditions were not exceptional or peculiar to Chicago, but may be considered as general and common to all large towns in which the improvements suggested by the most recent experience and knowledge have not been adopted. Many particular defects are described, and cases of sickness that were traced to them noticed. Illustrations are given of bad drainage in actual houses whose appearance promised a better condition. The dangers which bad sewers and drains entail are forcibly presented; and suggestions are given for remedying and preventing the evils which they occasion.

THE WILDERNESS-CURE. By MARC COOK, author of "Camp Lou." New York: William Wood & Co. Pp. 153. Price, $1.

"CAMP LOU" was a magazine article which related how the author, being in a decline with lung-disease, was restored to health by camping in the Adirondacks. It called out more inquiries for minor details than the writer could answer individually, and he has therefore put all the information that was sought in the questions in this little volume. The book describes the "Wilderness" country and the conditions of the camp; considers the practicability of weak persons wintering in the region described, furnishes a summary of several cases that have been treated in the method recommended, or one like it, and considers the questions of necessary outfit and expense.

A TEXT-BOOK OF ANATOMY, PHYSIOLOGY, AND HYGIENE. By J. T. SCOVELL. Terre Haute, Indiana: Moore & Langen, Printers. Pp. 88, with six plates.

THIS work is designed as a text-book, to be supplemented with the study of other works more completely discussing the points considered, of which a partial list is given. It presents the principles of the science plainly, clearly, and briefly, in well-framed sentences, and is arranged after a logical classification of the divisions and subdivisions of the subject. In addition to this, the section on hygiene is practical. The illustrations are given in engravings in separate plates.

PUBLICATIONS RECEIVED.

Extra Census Bulletin. Report on the Cotton Production of the State of Louisiana. By Eugene W. Hilgard. Illustrated. Washington: Government Printing-Office. 1881. Pp. 99.

Studies in Astronomy. By Arthur K. Bartlett. Published by the author. Battle Creek, Michigan. Pp. 56. Price, 35 cents.

"The Utah Review." Rev. Theophilus Hilton, A. M., Editor. Vol. I, No. 1. July, 1881. Salt Lake: H. P. Palmerston & Co. Monthly. Pp. 31. $2 a year.

Report of Field Experiments with Fertilizers. By Professor W. O. Atwater. 1880. From the Report of the Connecticut Board of Agriculture. Pp. 56.

First Annual Report of the Astronomer in charge of the Horological and Thermometric Bureaus of the Winchester Observatory of Yale College. By Leonard Waldo. New Haven. 1881. Pp. 32.

"The Journal of the American Agricultural Association." Vol. I, No. 1. Joseph H. Reall, Editor. New York. Published by the Association. 1881. Pp. 260.

Report on Hawaiian Leprosy. By A. W. Saxe, M. D. Illustrated. Santa Clara, California. 1881. Pp. 26.

To the English-speaking Populations in America, Europe, Asia, Africa, and Oceanica, concerning Testimonials on "Origin, Progress, and Destiny of the English Language and Literature." By John A. Weisse, M. D. New York: J. W. Bouton. 1881. Pp. 49.

Proceedings of the California Pharmaceutical Society and College of Pharmacy, and Report of the Twelfth Annual Meeting held at San Francisco, January 13, 1881. San Francisco: Joseph Winterburn & Co. 1881. Pp. 66.

The Reasoning Faculty of Animals. By Joseph F. James. Reprint from "The American Naturalist." Pp. 12.

A Great Lawyer. By Charles C. Bonney. Chicago: Legal News Co. 1881. Pp. 12.

"The Hour-Glass: A Popular Weekly Illustrated Journal." Chicago: Everett W. Fish & Co. Vol. I, No. 4. July 30, 1881. Pp. 6. 50 cents a year.

Report of Professor Spencer F. Baird, Secretary of the Smithsonian Institution, for the Year 1880. Washington: Government Printing-Office. 1881. Pp. 83.

On Maximum Synchronous Glaciation. By W. J. McGee. Salem, Massachusetts. 1881. Pp. 65.

A Memoir upon Loxolophodon and Uintatherium. By Henry F. Osborn, Sc. D. Accompanied by Stratigraphical Report of the Bridge Beds in the Washakee Basin. By J. B. McMaster, C. E. Illustrated. Princeton, New Jersey. Pp. 54.

Report of the Chief of the Bureau of Statistics for Three Months, ending March 31, 1881. Washington: Government Printing-Office. 1881. Pp. 100.

The University of Texas. By Professor Alexander Hogg. Pp. 7.

Circulars of Information of the Bureau of Education. Nos. 6 and 7, 1880, and 1 and 2, 1881. Washington: Government Printing-Office. 1881.

Fashion in Deformity. By Professor W. H. Flower. London: Macmillan & Co. 1881. Pp. 85. 75 cents.

The Foreigner in China. By L. N. Wheeler, D. D. Chicago: S. C. Griggs & Co. 1881. Pp. 268. $1.25.

The Bible and Science. By T. Lauder Brunton, M. D., F. R. S. London: Macmillan & Co. 1881. Pp. 415. $2.50.

A Sketch of Ancient Philosophy, from Thales to Cicero. By Joseph B. Mayor, M. A. Cambridge: University Press. 1881. Pp. 254. 75 cents.

Botany. Outlines of Morphology, Physiology, and Classification of Plants. By W. R. McNab, M. D., F. L. S. Revised for American Students by Charles E. Bessey, Ph. D. Pp. 400. $1.10. And English History for Young Folks. By S. R. Gardiner. Revised for American Students. Pp. 457. $1. New York: Henry Holt & Co. 1881.

The Microscope and its Revelations. By William B. Carpenter. Sixth edition. Philadelphia: Presley Blakiston. 1881. Pp. 882. $5.50.

Catalogue of 1,098 Standard Clock and Zodiacal Stars. Prepared under the Direction of Professor Simon Newcomb. Pp. 314.

Indigestion and Biliousness. By J. Milner Fothergill, M. D. New York: William Wood & Co. 1881. $2.

The Ancient Bronze Implements, Weapons, and Ornaments of Great Britain and Ireland. By John Evans, D. C. L., F. R. S. New York: D. Appleton & Co. 1881. Pp. 509. Illustrated. $5.

POPULAR MISCELLANY.

The American Association at Cincinnati.—The thirtieth meeting of the American Association for the Advancement of Science began at Cincinnati August 17th, and was one of the largest and every way most successful that the body has held. There was an unusually strong influx of new members, and the regular working force of the Association was well represented. The papers were many and varied, and some of them results of able investigation, and showing a well-sustained activity of original research. As regards provision for the social entertainment of the members, Cincinnati demonstrated that it understands this matter quite as well as Boston, and is not to be outdone. Every arrangement for the comfort and the pleasure of the scientists was perfect, and those who experienced them will long remember the enjoyments of the occasion. We can not, of course, report the work, and can only refer to some of the more important papers.

The meeting began with a welcoming address by Judge J. D. Cox, of Cincinnati, and a response by President Brush. The anthropological and archæological departments were fully represented, a large proportion of the most instructive and most novel papers bearing upon that subject. The proceedings of this sub-section were opened with an important and highly interesting address by the chairman, Colonel Garrick Mallery, on "The

Gesture-Speech of Man." Professor Mason read a paper on "The Uncivilized Mind in the Presence of Higher Phases of Civilization," the more immediate bearing of which was on the subject of Indian education; Horatio Hale, in "A Lawgiver of the Stone Age," sought, among other things, to inquire whether mental capacity increases with the progress of civilization, introducing in illustration the condition of the Iroquois when first visited by Europeans; Major William I. Beebe, of Brooklyn, read a paper of suggestive import on "The Decipherment of Inscriptions from the Mounds," to which we have referred more fully in another place; Mr. W. J. Hoffmann discussed "The Interpretation of Pictographs by the Application of Gesture-Signs"; Mr. Watson C. Holbrook, "Prehistoric Hieroglyphics"; while Mrs. E. A. Smith communicated the results of her researches on the "Animal Myths of the Iroquois." Dr. Stephen D. Peet contributed observations on "The Emblematic Mounds of the Four Lakes of Wisconsin," and on the "Buffalo Drives on the Rock River, in Wisconsin," a paper which provoked considerable discussion. Judge John G. Henderson discussed "Agriculture and Agricultural Implements of the Ancient Inhabitants of the Mississippi Valley"; and Mr. De Saas, of the Bureau of Ethnology, Washington, summarized the whole subject in his paper on the "Progress of Archæological Discovery." After this a resolution was passed, and referred to the Standing Committee, asking Congress to continue the appropriations for investigations relating to the mound-builders and to prehistoric mounds. The Association resolved to exercise its influence to preserve the great mound at Cahokia, Illinois, which is about to be sold; and excursions were made to Fort Ancient, one of the best-known earthworks in the Ohio Valley, and to Madisonville, where some very interesting discoveries have recently been made. In the microscopical department, Dr. G. M. Sternberg, of Baltimore, offered contributions to the study of bacterial organizations commonly found on mucous surfaces and in the alimentary canal of healthy individuals, in which he combated the opinion that each disease is produced by a microbe peculiar to itself. He had never found living organisms in blood, healthy or diseased, but the alimentary canal was never without parasites. Dr. Lester Curtis, of Chicago, gave the results of the study of the blood of Griscom, who fasted forty-five days at Chicago, the genuineness of whose fast he attested; the blood appeared healthy in every particular throughout the fast and at its end. Among the papers on subjects of physics were one "On the Cause of the Arid Climate of the Far West," by Captain C. E. Dutton; one on "The Effect of Prolonged Stress on the Strain in Timber," by Professor R. H. Thurston; and one on "Standard Time," by Professor E. B. Elliott, of Washington. A committee which had been appointed to consider the latter subject presented majority and minority reports. The former, by Professor Stone, favored a single standard for the whole country; the latter, by Professor Waldo, favored a number of standards, beginning with New York for the East, another at St. Louis, an hour later, for the Central West, and others at points farther West, each exactly an hour later than the preceding one, and suggesting that the New York standard be fixed at five hours after Greenwich time. The two reports were ordered published, to be considered at Montreal next year. H. C. Hovey presented a paper on "Coal-Dust as an Element of Danger in Mining," as shown by the late explosion in the Albion mines in Nova Scotia. Mrs. A. B. Blackwell read a paper on "The Constitution of the Atom of Science"; and Dr. H. B. Parsons, in a paper on the "Composition and Quality of American Wines," drew the conclusion that wines of American manufacture are in many cases as good as or better than more expensive foreign wines of the same general character. W. H. Ballou, of Evanston, Illinois, reviewed the "Natural and Industrial History of the White Pine of Michigan," and predicted that, at the present rate of usage, the supply of timber will disappear in seven years. Mr. Charles Sedgwick Minot, by an inquiry whether man is anatomically the highest animal, excited considerable discussion, in which, the newspaper report tells us, "some feeling was unfortunately created." David D. Thompson, of Cincinnati, considered the "Influence of Forests on Water-Courses," and W. J. Beal communi-

cated his observations of "The Motion of Roots in germinating Indian Corn." The chairman of the entomological sub-section, reviewing the growth of entomology in the United States, said that while forty years ago there were but ten working entomologists south of New York, the "Naturalists' Directory" for 1880 contains the names of four hundred and thirty-six entomologists. Professor Riley announced some novel views on the sudden appearances of the grasshopper pest, which seemed to indicate that he saw in them illustrations of the doctrine of evolution. A resolution was adopted disapproving the conferring of the degree of Ph. D. except after examination; and a committee was appointed to coöperate with the committee of the American Philological Association in addressing a memorial to the Boards of Trustees of all the colleges, asking them to discontinue the practice. The next meeting of the Association was appointed to be held at Montreal, August 23, 1882. The following officers were elected for the ensuing year: President, Dr. J. W. Dawson, of Montreal, Canada; Permanent Secretary, Professor Putnam, of Cambridge, to continue; General Secretary, William Saunders, of London, Ontario; Assistant General Secretary, Professor J. Eastman, of Washington, D. C.; Vice-President and Chairman of Section A, Professor William Harkness, of Washington; Section B, Professor T. C. Mendenhall, of Columbus, Ohio. Treasurer, William S. Vaux, of Philadelphia. A new committee on Geological Survey was appointed, consisting of Professors Swallow, Proctor, James, Hull, Winchell, Kerr, and Orton, and Major Powell. Steps were taken during the meeting toward the organization of a distinct Association of American Geologists.

Physiological Effects of Compressed Air.—Professor C. M. Woodward, of Washington University, St. Louis, Missouri, has written a book on the St. Louis Bridge, and in it has devoted a chapter to the review of the affections which the men employed in sinking the piers of the bridge suffered from compressed air, and the theories that were proposed to account for the trouble. From advance sheets of this chapter kindly furnished by the author, we learn that no serious drawback was perceived to working four or even six hours consecutively in the air-chamber till the cutting-edge of the caisson of the east pier was nearly sixty feet below the surface of the river. From that time on the working-time was gradually shortened and the rests were made longer, till the 5th of February, at sixty-five feet, when the work-time was made three watches of two hours each, with two-hour rests. The first effect noticed upon the men was a muscular paralysis of the lower limbs, without pain, which would pass off in a day or two, but which became more difficult to subdue, more extended and painful, as the caisson was sunk deeper. It was joked about among the men at first, but became more serious by the middle of February, after which, the depth being seventy-six feet, severe cases became more frequent. The superintendent noticed the fact that the sick men were often thinly clad and poorly fed. At the end of March, several persons having died within a few days shortly after coming out of the excavations, Dr. A. Jaminet was appointed to take medical charge of the men and establish such regulations as in his judgment their well-being demanded. He had been a frequent visitor to the air-chamber, had noticed the men as they came out, and had observed that their appearance was pallid and cold; that in some the pulse was quick but somewhat weak, while with others it was as low as sixty, and that without exception the workmen complained of fatigue; also that the pulse always quickened on entering the air-chamber, though it soon fell to the normal rate, and even lower; that the number of respirations increased and a feeling of exhilaration came on in the air-chamber, and that the workmen sweated profusely during their stay in it, although the temperature was often below 60° Fahr. The air-lock was, as a rule, excessively warm when the pressure was increasing, and excessively cold when the pressure was diminishing. On the day the caisson touched the rock, when the pressure was forty-five pounds above the normal, Dr. Jaminet was conscious of a great loss of heat and a violent pain in his head while in the air-lock on his way out; he had much difficulty in getting to his carriage, and became partly

paralyzed after he reached home, so that he considered his life in danger. All the precautions suggested by experience and careful observation were adopted for the protection of the men, and the cases of affection were watched as they occurred. In all, with six hundred men employed, one hundred and nineteen cases important enough to need medical treatment were reported at both piers, fourteen of which cases died and two were crippled. *Post-mortem* examinations were held in the cases of eight. Various theories have been proposed to account for the affection. Dr. Clark, of the City Hospital at St. Louis, believed that the congestion observed was caused by the forcing of the blood in upon the interior organs of the body in consequence of the increased atmospheric pressure. Another physician thought the men were poisoned by carbonic acid which had been abnormally retained within the system while in the air-chamber, but which was set free as soon as the pressure was removed. Dr. Jaminet thought the cases were due to physical exhaustion caused by breathing an atmosphere of quadruple strength, and supported his view by reference to the facts, all of which seemed to agree with it. Professor Woodward does not contradict his theory, but suggests in addition that the vital energies of the men taken sick were to a great extent paralyzed by loss of heat, which was due—1. To the expansion of the air in the lock while coming out; 2. To the expansion of the free gases and vapors within the body when relieved of the abnormal pressure; 3. To the liberation of the gases held in solution by the liquids of the body; 4. To the severe physical effort of climbing the stairs. The loss of heat taking place under diminution of pressure from four atmospheres to one would, if no heat were received from surrounding objects, be enough to reduce the temperature from 70° above to 106° below zero. Taking into consideration the condition of men who have been working hard, especially if they have not been well clothed and fed, it is not strange that they did, but rather that more of them did not, succumb under the combined effects of these four agencies. Dr. Jaminet gives an implied confirmation of these views by remarking in his pamphlet that "the paresis is but the result of reflex action caused by the spontaneous refrigeration of the whole system, but principally of all the abdominal organs." It is also worthy of remark that none of the men were ever attacked on entering the caisson, and none were ever sick while in the air-chamber, no matter how long the watch, but the attack always came on within half an hour after leaving the air-lock, or at the time. On the basis of this theory Professor Woodward establishes a system of rules for the management of men at work in compressed air, embodying the principles that only sound men should be employed, that they should be guarded against exhaustion, that they should not be exposed with unnecessary suddenness to the change from a compressed to the normal atmosphere; and that such a supply of heat should be given every man that he could lose a large amount and still have plenty left.

The Study of Anthropology.—M. P. Topinard classifies the anthropological sciences in three divisions. The first division, anthropology proper, is general, considering the questions of man's place in nature, and his origin, whether by special creation, or by derivation from preëxisting forms; and special, considering types, the classification and origin, the laws of the formation, development, death, and renewal of races. To the second division he gives the name of ethnography. It concerns the agglomerations of peoples, hordes, and tribes as we meet them. Its interest is derived from questions that are peculiar to it, and from the fact that races do not exist in nature, but are only abstractions, characterized by types which we imagine to have existed among ancestors. Nowhere can the real existence of a race be discovered, but we find two or three types, even among the most savage and most isolated tribes. Special ethnography relates to the description of each people; general ethnography to common questions of manners, customs, aptitudes, industries, beliefs, institutions; to the past of the race, the environment, circumstances in the evolution of humanity; to sociology. The third division includes the complementary sciences, among which archæology, especially prehistoric archæology, holds the first rank. It fur-

nishes us what we can learn of the primitive man, and is gradually bringing us nearer to the epoch when the races started pure. History adds legends and definite movements, records the acts and voyages of antiquity, and discloses the relations of ancient to modern races. The descriptions of the Scythians by Herodotus, of the Germans by Tacitus, of the Goths by Jornandes, of the Anglo-Saxons by Amédée Thierry, are examples of its direct relation. In return, history receives a certain degree of light from anthropology, and the hereditary influence of the physiological characters of races plays an important part in the present order. Linguistics, which should not be confounded with philology, helps to fill the gaps left by history and archæology, by indicating the passage of a people through a particular region. Deductions should be made from it with careful consideration, for they are worth no more than those which may be drawn from a custom, a mythological form, or a funeral rite. A language may advance or retire without involving the question of anthropology. We pass for Aryans, because our ancestors spoke an Aryan language; but that language may have been brought to them from the East by a small, more highly-civilized group. The group disappeared, the language remained with the aborigines. Demography is an anthropological science, related to ethnography. A fourth division might be added, consisting of sciences to be consulted. Among them might be included geography, as showing the distribution of peoples, and the topographical conditions of their surroundings; comparative law, as illustrating their social and legislative organizations; architecture and music, which show that all people and races have not had the same sentiments; sculpture, etc. The studies of anthropology, whose final object is to solve the problems of the evolution of the human race and man's place in nature, begin with analysis, or the examination of particular characteristics. Human characteristics may be arranged, according to their bearing on anthropology and ethnography, in five orders: External physical traits; internal physical traits; physiological traits; pathological traits; and ethnic traits. The last include all that can distinguish one people from another, whether relating to race, surroundings, tradition, or other points. Among them may be indicated polygamy, polyandry, monogamy, burial customs, the Indian custom of scalping, Polynesian *taboo*, the use of bows and arrows and of the boomerang, artificial deformations of the skull, etc. Thus the principal anthropological studies may be said to turn round four centers: the characteristic, the type, the race, and the human species.

The Great Primitive European Sea.—The theory of the former existence of a great sea embracing the basins of the Black, Caspian, and Aral Seas, has been confirmed by the recent ichthyological investigations of the Russian academician Kessler. This sea in the Miocene period, resting on a bottom of Eocene chalk and Jurassic rock, extended over a bed which, beginning in the East with the Sea of Aral, included the lowlands of the Caucasus and the plains of the Pontus, reached Volhynia, Podolia, and Galicia, the flats of the lower Danube, Hungary, and Servia, and ended in the West beyond the Vienna basin. This great sea was, at least in the latter part of its existence, brackish, and was connected (though some dispute this), as northern species among the fosils indicate, either through a strait or by overflow, with the Arctic Ocean. The area of the sea was still more extensive in the Eocene period, and in the Jurassic time it seems to have included all of central Russia and reached to Courland. The separation of the Aral and Caspian Seas from the Black Sea took place very early, probably during the Pliocene age, certainly before the beginning of the last geological period. The connection of the Black Sea with the Mediterranean through the present straits was made considerably later. The separation was accompanied with a decrease in the saltness of the Eastern seas—the Black Sea now containing 1·6 per cent., the southern part of the Caspian Sea 1·3 per cent., the Sea of Aral 1·1 per cent. of salt—and a slight modification of their fauna. The fauna of the Black Sea can not be regarded as an impoverished fraction of that of the Mediterranean, but is of independent origin, consisting of what remains from the primi-

tive sea, to which a few Mediterranean forms have since been added. The fauna of the Caspian is analogous to that of the Black Sea, but without the Mediterranean species. Since this sea is composed of brackish water, and is fresh in the northern part, it can contain only those species which live in brackish water or are indifferent or migratory, with no real sea-fishes. The ichthyology of the Sea of Aral has only recently been determined. It is entirely of a fresh-water character.

NOTES.

MR. M. L. WADSWORTH has published at Cambridge, Massachusetts, the results of a microscopical study of the iron-ore, or peridotite, of Iron-Mine Hill, Cumberland, Rhode Island, a valuable ore similar to the ore of Tagberg, Sweden, of which an immense quantity occurs in mass. He also, in the same pamphlet, describes a gold-mine, which is worked for its gold, in the quartz veins of the diabase of Sullivan, Hancock County, Maine.

MR. ALFRED NEIGHBOUR, apiarian, of London, has made a successful shipment of queen humble-bees to New Zealand. Of eighteen bees which were sent on the 7th of December last, two were alive and strong when the lot reached the consignee on the 3d of February, and flew at once against the wind into the clover-fields. These are the first humble-bees that have ever lived in New Zealand, all former attempts to ship and acclimatize the insects having failed.

A MOVEMENT is on foot in England, and is receiving the countenance and support of members of Parliament, to reduce the time of labor of railway employees to nine hours a day. In behalf of the change it is urged that the duties of the men, and especially those performed by the engineers and signal-men, are of a nature to require the keenest and most unflagging attention, and that this can not be given for many hours continuously without great fatigue, and a consequent diminution of the alertness and care necessary to the safety of life and property.

WHILE other nations of Europe, and the United States, have established stations around the north pole for the study of terrestrial magnetism, France is about to establish one among the islands of Cape Horn. Credits for this purpose are to be asked of the Chambers, and it is anticipated that the expedition will go out in the same vessel that carries the astronomers deputed to observe the transit of Venus.

PROFESSOR TROWBRIDGE, who was appointed a committee of the New York Academy of Sciences on the subject of procuring the adoption of a uniform system of mathematical notation, or symbolization, has reported that uniformity would be very desirable, but hard to gain. It prevails essentially in pure mathematics, where the algebraic signs and the symbols of calculus are everywhere the same, but not in applied mathematics, where even the most common symbols are employed without discrimination, and according to each writer's whim and convenience. The realization of uniformity would be almost equivalent to the reconstruction of a language, and would require continued efforts and discussions. The most that the Academy can accomplish toward it at present is to take a position in favor of it.

THE fifty-fourth meeting of the German Association of Naturalists and Physicians will be held in Salzburg, September 18th to 24th. Addresses will be delivered at the general meetings by Dr. von Pettenkofer, on the soil and its connection with the health of man; by Dr. von Oppolzer, of Vienna, on the sufficiency of Newton's law of gravitation to explain the motion of the heavenly bodies; and by Herr Mach, of Prague, on natural-history teaching.

THE death of the eminent German botanist, Professor M. J. Schleiden, is announced. Professor Schleiden was born at Hamburg in 1804, and turned his attention to botany after having studied law. He was Professor of Botany at Jena from 1839 to 1862, and of Vegetable Chemistry and Anthropology at Dorpat in 1863 and 1864. His principal work is "Die Grundzüge der wissenschaftlichen Botanik" ("The Principles of Scientific Botany").

M. PASTEUR has reported the complete success of the experiments which he has been carrying on on a large scale at a farm near Melun, France, in vaccination against carbonaceous diseases; and he believes that he has obtained a process by means of which sheep and cattle can be made wholly secure against this most dangerous and destructive class of maladies.

THE report of Professor Abel on colliery explosions confirms the theory that coal-dust is an important factor in them. A mixture of coal-dust and air is not explosive, but if a quantity of fire-damp, which, mixed merely with air, would be harmless, is also present, a highly explosive atmosphere is produced. Professor Abel's experiments show that any kind of dust mixed with air, containing a small quantity of fire-damp, converts the mixture into an explosive compound.

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